FOUNDRY TRADE JOURNAL
Established 1902
WITH WHICH IS INCORPORATED THE IRON AND STEEL TRADES JOURNAL

Vol. 80 Thursday, September 19, 1946 No. 1570

49, Wellington Street, London, W.C.2
'Grams : " Zacatecas, Rand, London "
'Phone : Temple Bar 3951 (Private Branch Exchange)
PUBLISHED WEEKLY : 21s. per annum (Home and Overseas)

Youth Recruitment

The Royal Borough of Kingston-on-Thames, in Surrey, has issued a beautifully illustrated booklet carried out on art paper called " Youth." It details the activities of the various local groups such as boy scouts, girl guides, swimming, cycling, young farmers, and so forth, but—and this is important—a number of local firms have taken page advertisements to tell both parents and children of the advantages to be gained by working in their particular establishments. We hear that a nearby town—Esher—has issued a similar publication. Thus it may be that the movement is general throughout the country—in any case it is likely to spread.

Now it so happens that the Council of Iron Foundry Associations possess a series of film strips, which have received universal approbation as a means of recruiting youth to the industry. Thus, any foundry concern which takes space in such booklets should invite the local youth to a free film show. Though the film may not match up with local production, stress can be laid on the fact that youth welcomes removal from one locality to another after training. A craft training opens up this vista.

The textile industries probably lead all others both in volume and quality of their publicity directed to youth. The cost must have been very considerable and its emulation by the foundry industry would require more money than is at present available to employers' federations. It is obvious that competition for youth recruitment is already keen, and is likely to become excessive. The reasons are obvious. There is the later school-leaving age, the period of military service, and the low birth rate for the period under consideration, and for the time being—especially in so far as it concerns the young demobilised Servicemen—the chance of " easy money " in the black market.

A number of go-ahead foundries, because of the pre-occupation with extensions, reorganisations, and the provision of employee amenities, are postponing youth recruitment until they have carried through these activities, as they rightly wish to do something really worth while in this direction. We think they are adopting a wrong policy, and are of opinion, that by the time they feel they can launch out with a proper well-thought-out scheme, they will be too late and will find that their organisation is badly out of balance. Logic alone demands recruitment before training, and a small training organisation should be set up immediately. Many concerns report equal difficulty in recruiting girl labour. In a way this is more valuable than boy labour because there is no break to be envisaged for military service, and thought should be given to its increased utilisation for the lighter repetition jobs. The war years have clearly demonstrated the real worth of female labour in quantity production; some concerns managed with 90 per cent. of their labour, girls, and still turned out an impeccable production. Naturally, they require more mechanical equipment, slightly lower benches, but in our various trips round foundries we are constantly seeing jobs performed by youths and men, for which quite young girls are well suited. Thus there is need for a modicum of the propaganda of the industry to be devoted to this valuable class of neophyte.

THE INSTITUTE OF METALS have issued No. 3 of their Monograph and Report Series (286 pp., ill., 7s. 6d. post free), being " Atomic Theory for Students of Metallurgy," by Dr. W. Hume-Rothery, of Oxford. This authoritative summary is primarily intended for metallurgical students reading for honours degrees, and is striking evidence of the volume of work done in atomic physics in relation to the metals. Properties to which atomic theory offers a reasonable explanation are dealt with, but these are physical rather than engineering properties.

Contents

Youth Recruitment, 53.—F.B.I. Conference on Export, 54.—New Catalogues, 54.—A Note on Coreprints, 54.—Book Review, 54.—Some Notes on Hard Wear-Resisting Cast Irons and Steels, 55.—Institute of Metals, 61.—German Non-Ferrous (Copper Base) Foundry Industry, 62.—Correspondence : Corrosion of Castings, 62.—Annealing Rate in Gaseous Malleablising, 63.—Book Review, 69.—Design for Magnesium Castings, 69.—Forthcoming Events, 69.—Compressed Air in the Foundry, 70.—Methods of Making Cast-Iron Shells, 71.

F.B.I. CONFERENCE ON EXPORT

A two-day conference on export has been organised by the Federation of British Industries, and is to be held in the Central Hall, London, on November 27 and 28. The conference will be opened by Sir Clive Baillieu, president of the F.B.I., and presided over by Mr. Leslie Gamage, member of the Grand Council of the F.B.I., president of the Institute of Export, and chairman of the British Export Trade Research Organisation.

The Rt. Hon. Sir Stafford Cripps, M.P., President of the Board of Trade, will speak at the opening session on the significance of exports to the national life. At this session, Mr. Leslie Gamage will outline the objectives of the conference, and the Rt. Hon. S. M. Bruce, formerly High Commissioner for Australia in London, will speak on British exports from the point of view of the Dominions. The subject to be discussed at the second session of the conference is "The Functions of Government and of Industry in relation to the Export Trade," the principal speakers being Sir John Woods, permanent secretary to the Board of Trade, and Sir Norman V. Kipping, director-general of the F.B.I.

At the morning session on the second day of the conference, the subject will be "Production for Export and its Relationship to Production for the Home Market," when the speakers will be Lt.-Col. H. B. Riggall, member of the Grand Council of the F.B.I., president of the British Engineers' Association, and Mr. E. W. Goodale, member of the Grand Council of the F.B.I. "Export Selling" is the subject of the final session, when the merchant's selling methods will be discussed by Mr. E. A. Carpenter, vice-president of the Manchester Chamber of Commerce, and the manufacturer's selling methods by Sir Frederick Bain, deputy-president of the F.B.I.

NEW CATALOGUES

Heavy Grinding Machines. A 28-page well-illustrated catalogue covering a line of heavy plane grinding machines, such as are used for finishing rolls, has been received from the Churchill Machine Tool Company, Limited, Broadheath, near Manchester.

A.C. Arc-welding Electrode Holder. The General Electric Company, Limited, of Magnet House, Kingsway, London, W.C.2, have sent us an eight-page pamphlet which illustrates and describes a safety type of electrode holder capable of continuous welding duty at currents up to 300 amps., and designed to operate with electrodes up to 4 s.w.g. It weighs only 24 oz., and gives both safe and comfortable conditions for the operator.

MR. H. GRAY, chief draughtsman of the engineering department of Edgar Allen & Company, Limited, Imperial Steel Works, Sheffield, has retired. He will be succeeded by MR. A. WADSWORTH, of the British "Rema" Manufacturing Company, Limited, a subsidiary of Edgar Allen & Company.

A NOTE ON COREPRINTS

By "CHIP"

What at first appears to be the obvious method to adopt for the shape and position of a coreprint, is not always the best. This is because of certain peculiarities of design and difficulties associated with core assembly. A simple case is illustrated in Fig. 1, which shows a scrap view of one foot of a particular type of cylinder, the joint of the mould being along line AA, necessitating the portion between the ribs being cored out. The first impression of a suitable coreprint would invariably be as dotted line C and of width D, but experience has shown that with this type of print, unless extraordinary care is exercised—

FIG. 1.

especially after the pattern and core boxes have been in use for a while—defective castings acrue because of loose sand in the foot portion, E. This is often carried down by the core on assembly.

If clearance was allowed to ensure the core entering easily, it is probable that before long excessive "flash" would be found, necessitating extra work in the fettling shop to trim up and make the casting of better appearance.

A better way is to make the coreprint right down to the bottom of the foot and the overall width of the core, plus the thickness of the ribs B. Thus the core contains the two ribs B and the foot, and can be easily inserted in the mould without fear of causing the trouble experienced with the former method.

BOOK REVIEW

Experiments on Coking Practice—The Effect of Type of Oven upon the Properties of Coke. Published by the Department of Scientific and Industrial Research, through H.M. Stationery Office, Kingsway, London, W.C.2. Price 4s. net.

This mimeographed report, carried out in foolscap size, describes a series of tests carried out just before the war on six industrial plants. Three coals only were used owing to the outbreak of war, when the tests were discontinued, and no worthwhile conclusions have been drawn. Some tests made by the B.C.I.R.A. are also included, but the interpretation of these is not such as to have any practical application.

V. C. F.

SOME NOTES ON HARD WEAR-RESISTING CAST IRONS AND STEELS*

French exchange Paper to the Institute of British Foundrymen

By MARCEL BALLAY (Vice-president, A.T.F.), and RAYMOND CHAVY (Member of Committee, A.T.F.)

Knowledge of the subject of friction and resistance to wear is still very limited, and long patient research will still be necessary to formulate a coherent theory, the need for which is constantly felt essential when dealing with new applications. Whilst awaiting the results of fundamental research and an extended period of observation work to provide these lacking foundations, one must build on what is available. At the present moment, the choice of material is governed by the analogy of similar cases and by the use of rules, which cannot be explicitly stated, because they are subject to so many exceptions. One of these rules is that hard materials should be used where rapid wear is involved, hardness being here defined as resistance to penetration (Brinell, Vickers or Rockwell hardness), but it is well known that certain wear problems have been solved by the use of austenitic steels with 13 to 15 per cent. manganese, which have only a moderate ball hardness.

For comparing the wear-resisting properties of such different materials as rubber and tungsten carbide, it is obvious that hardness figures are not much use. However, under certain particular conditions of wear, it appears that resistance does not increase with hardness, at least for certain types of alloys. Case-hardened and quenched steels; electrolytic chrome plating for many engineering components; chilled cast iron for rolling-mill rolls; tungsten carbide for wire-drawing dies, are all well-known examples of the use of hard materials.

Of this crowded and extensive field of wear-resisting materials, the Authors propose to review, very incompletely, a certain small section, namely, ordinary and alloy grey cast irons, white iron, and, finally, an alloy steel which they have specially studied for reasons which will become clear later.

For nearly 20 years the Authors of this Paper have been involved very closely in the study, the manufacture in the foundry, and the industrial development in France, of special grey or white hard cast irons. It seemed to them that some of the observations they have made, and the conclusions they have reached, might be of interest in helping to a better knowledge of wear-resisting materials. They have, therefore, endeavoured to make clear the diversity of solutions which metallurgy has to offer at the present moment in this field.

Early Developments

It was with the appearance of the so-called semi-steel or pearlitic cast irons during the 1914-18 war that a real beginning was made in the understanding of the rôle of the structure of cast irons and the potential usefulness of these materials.[1]

The close similarity between grey cast irons and steel, from which they only differ in the broad sense by the presence of graphite in the cast iron, was bound to lead to development of alloy cast irons and to heat-treatment of cast irons.

However, experiments on addition of alloying elements (nickel, chrome or molybdenum) to cast iron had another object, namely, action on the graphite, or to make the cast iron more homogeneous by avoiding troublesome variations in the iron carbide content. That was the first stage. The second stage was the transformation of pearlite into sorbite, martensite, or austenite. In 1928 the Authors showed that the addition of carefully chosen alloying elements would provide a wide range of cast irons possessing similar properties to steel as regards critical quenching speeds.[2] Since then they have shown that it is possible to use cast irons quenched in oil, in air or simply cooled in the mould, whilst insisting on the rôle of tempering, which relieves stresses, reduces brittleness and allows of the required hardness being very closely obtained.

Industrial Applications

From that time industrial applications have been numerous. For instance, hard grey cast irons can be used for the following diverse purposes, for which a typical French example is quoted in each case.

(*a*) *Sorbitic structure as-cast, with no heat-treatment.* Alloy elements added to the cast iron increase the level of hardness. As examples, reference is made to cams for bottle-washing machines, these being $\frac{1}{4}$ in. to $1\frac{1}{2}$ in. thick, weighing between 33 lb. and 88 lb. These components are subject to fairly rapid wear by the rollers they actuate, which are guided in a groove involving fairly heavy strains and stresses. These cams are made of a sorbitic nickel-chrome cast iron to the following composition:—T.C., 2.8 to 3.1; Si, 1.5 to 1.8; Mn, 1.2 to 1.5; P, 0.3 max.; Ni, 2.5 to 3.0; and Cr, 0.4 to 0.6 per cent.

The minimum Brinell specified by the makers is 260. The average figure obtained on the castings is 270 to 300. It was considered inadvisable to heat-treat these castings owing to their complex design and the danger there might be of slight distortion in the roller track.

(*b*) *In the quenched and tempered state, the casting being machinable in the "as-cast" condition.* It is not proposed to enlarge upon this group of applications which is well known today. A very wide range of

*Translated by R. W. Allott, M.A. (Nitralloy, Limited, Sheffield).

Hard Wear-resisting Cast Irons

components has been made in cast iron, machinable "as-cast," quenched and tempered, including: motor cylinder liners, gears, shaping or stamping dies, etc. It should be emphasised that water quenching of cast iron is possible only in certain exceptional cases, whilst oil-quenching is suitable for castings of not too complicated design, but air hardening must be used for difficult jobs. Low temperature annealing at 150 to 300 deg. C. is always advisable after quenching.

Aero-engine Cylinders

(*c*) *In the tempered condition, the casting being martensitic, i.e.*, very hard and unmachinable in the "as cast" condition. One of the first applications in France was the Potez aero engine cylinder in 1930. These were 3, 6 or 9 cylinder radial engines for civil passenger aircraft, which had to be cheap and give long life. The first cylinders had been made of ordinary pearlitic cast iron but their performance was not satisfactory owing to the fairly high compression in these engines. The solution was found by using a cast iron with a fairly low carbon content to give the high mechanical characteristics required, with alloy elements added to modify the structure to allow of heat-treatment. The chemical composition was as follows:—T.C., 2.8 to 3.0; Si, 1.8 to 2.2; Mn, 1.0 approx.; P, 0.4 to 0.6; Ni, 4.0 to 4.2; and Cr, 0.0 to 0.3 per cent.

When made in this cast iron, the cylinders had in the as-cast condition, a grey martensitic structure with a Brinell of 360 to 400. For machining, the castings were slowly heated in the furnace to 500 to 550 deg. C., held at that temperature for about 1 hr., and very slowly cooled. The hardness of the cylinder was thereby reduced to 300 to 330. The very slow speed of heating and cooling was necessary to avoid cracks at the flange joints which might form the starting points for fractures.

On a test 6-cylinder radial engine, after 1,000 hrs. running, corresponding to over 62,000 miles running, the wear was found to be less than 0.04 mm. average on diameter. It should be noted that similar results have been recently obtained on wet liners treated to give the same hardness. After 400 hrs. on the test bench under severe conditions, with a synthetic oil lubricant, wear was very slight.

Results of the same nature, but much more important, have been recently obtained with cylinder blocks for engines for tanks and for Diesel engine locomotives. These engines, which are fairly high stressed for compression and speed, showed a very great loss of power, even during the first period of acceptance tests, when the cylinders were made of ordinary cast iron. In view of the complex design and of the fact that it is impossible to treat after machining, it was decided to use a grey martensitic cast iron, heat-treated so as to reduce the hardness to 300 to 340. The chemical analysis was approximately as follows:—T.C., 2.9 to 3.2; Si, 1.5 to 1.8; Mn, 1.5 to 2.0; P, 0.3 to 0.4; Ni, 3.8 to 4.5, and Cr, 0.3 to 0.6 per cent. The hardness specified by the customer for the casting, "as-cast," was 360 Brinell minimum.

The average hardness obtained has been from 380 to 420. According to the hardness "as-cast," the reheating temperature could be varied between 500 and 600 deg. C., with slow heating and cooling in all cases, to avoid cracks which might have been caused in view of the complicated design of the component and the extreme thinness of the walls.

Wire Drawing Drums

(*d*) *In the quenched condition with or without, hard cast-iron (martensitic), in the as-cast condition, tempered to allow of machining and then treated.* A typical example is for winding drums for drawing very fine wire. These are hollow cylinders 8 in. diameter by 16 in. long. The drums are subject to abrasion by the very fine wire of nickel-chrome alloy for resistance elements and they also regulate the tension necessary for drawing the wire. The wire has a tendency to bed into the surface of the cylinder, with resulting difficulty in unwinding. A nickel-chrome cast iron of the following composition was tried:—T.C., 2.8 to 3.2; Si, 1.5 to 1.8; Mn, 1.2 to 1.5; P, 0.4 max; Ni, 2.8 to 3.2; and Cr, 0.4 to 0.6 per cent.

Owing to the relatively thin wall, the cast iron is fairly hard to machine and the machine-maker decided to have a tempering treatment as 600 to 650 deg. C. applied before turning. In this condition, the metal has a Brinell hardness of 220 to 240. After turning, the piece is quenched in oil at 850 deg. C., which brings the hardness up to about 450 Brinell. No tempering is done provided that the parts are not liable to any shock in service. The life of the drum has been increased five-fold by this method.

(*e*) *Hardening and tempering of a cast iron, austenitic in the as-cast condition.* This solution of the problem of hard machinable cast irons has had few applications. Delbart and Lecœuvre [3], however, have reported the production of steam engine slide valves and drill guides in a cast iron (austenitic) as-cast, the composition being: T.C., 2.65; Si, 1.81; P, 0.074; S, 0.025; Mn, 3.75; Ni, 6.50 per cent. This iron, quite machinable as-cast, can be hardened by a prolonged tempering at 500 to 600 deg. C. The mechanical properties given by Delbart and Lecœuvre are:—

Brinell Hardness.	Tensile Strength.	Compressive Strength.	Transverse Strength (Frémont Test).	Deflection (Frémont)	Modulus of Elasticity.
	Tons per sq. in.	Tons per sq. in.	Kg.	mm.	Tons per sq. in.
As-cast .. 160	13	26	429	0.42	7,500
Tempered at 600 deg. C. 15 min. .. 418	20.6	33	610	0.25	6,860

The field of cast irons with high carbon, 3.5 to 4 per cent. does not seem to have been sufficiently explored. It would, however, seem of interest to use

• Frémont Test-piece 10 × 8 × 40 mm. Tested between 30-mm. centres, loaded at centre.

cast irons containing a large amount of graphite as this element is very useful against friction. For example, comparison may be made between cast irons containing 3 to 4 per cent. carbon as compared with the same amount of combined carbon in each, namely, 0.6 per cent.; the 4 per cent. carbon cast iron contains 40 per cent. more graphite than the 3 per cent. carbon cast iron.

The fact that if these high carbon cast irons are no longer used is due to their inferior casting properties, and also to their mediocre mechanical properties. It would appear that carefully balanced alloy additions giving greater hardness to the matrix of the iron and also a finer distribution of the graphite ought to be of interest. The addition of nickel and molybdenum meets these requirements. Below are given the comparative properties of two crucible melted cast irons, cast with an inch runner:

	Ordinary Cast Iron.	Ni-Mo Cast Iron.
T.C.	3.96	3.95
Si	1.49	1.59
Mn	0.60	0.60
Ni	0	1.25
Mo	0	0.35
Brinell hardness (3,000/10)	157	204
Transverse Frémont	457 Kg.	605 Kg.
Transverse Modulus	20.3 tons	27 tons
Shear stress	13.2 ,,	17 ,,

These cast irons have been used with success particularly for motor-car piston rings. The cooling of these components in the mould is rapid, and they are therefore martensitic in the cast state. They are tempered to soften them for machining, after which they are given a complete heat-treatment, quenching and tempering, to give a Brinell hardness of 300 to 330.

White Irons

Another group of cast irons, still not well known to founders, is the white cast irons. The carbide structure, without graphite, can be obtained by rapid solidification, against chills, of a cast iron of inherently low quenchability, or by ordinary cooling in a sand mould if the composition is properly controlled. With non-alloy cast irons the possibilities are very limited since modification can be effected only by change in carbon content, and both hardness and brittleness increase with increase in carbon content.

The use of alloying elements increases the possibilities considerably, since it then becomes possible to act on the pearlite, transforming into sorbite, martensite or austenite. The same hardness can be obtained with varying degrees of brittleness and it is possible to raise very considerably the upper hardness level of ordinary cast irons. By this means very wide modifications are therefore available, particularly as the corrosion resistance, heat resistance at high temperatures, and the magnetic qualities are also modified.

The possibility of increasing the hardness of white irons at the same time as raising their toughness is shown in Fig. 1, where typical results are given of 19 white irons[4]. Ordinates show the energy required to break cylindrical test-pieces 11.3 mm. diameter (0.452 in.) on supports 30 mm. (1.2 in.) apart, with pendulum load of 1.5 kgs. (0.68 lb.). Abscissæ show Vickers hardness numbers (50 kgs. load) taken on the same test-pieces. It will be seen that for a given hardness the ordinary cast irons show a lower toughness.

Toughness is obviously a very important quality for such parts as lining plates or hammers for crushers, coke-crushing discs, pulveriser beater bars, etc. Only a few typical recent applications of alloy white irons made in France will be cited:—

(*a*) *Cast irons, white as sand-cast.* Many alloy white irons have been used for parts subject to wear by erosion or abrasion. Amongst recent applications may be mentioned coke crushers for producing coke fines for motor-car gas producers. These components, which were previously made in 13 per cent. manganese austenitic steel, have recently been made in a nickel-chrome white iron of the following composition:—T.C., 3.4 to 3.6; Si, 1.0 max.; Mn, 1.2 to 1.5; P, 0.4 max.; Ni, 3.2 to 3.5; and Cr., 1.8 to 2.2 per cent. After simple cooling in the mould this cast iron has a

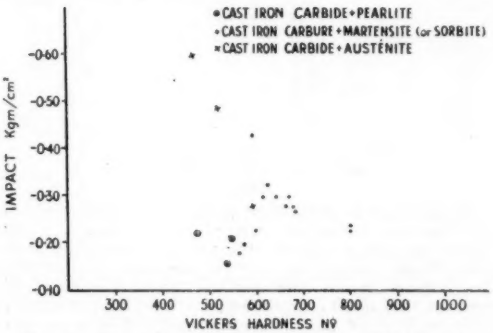

FIG. 1.—SHOWING THE HARDNESS AND TOUGHNESS POTENTIALITIES OF WHITE CAST IRON.

cementite-martensite structure, giving a Brinell hardness of the ordr of 650 to 700. In this case, the life of the parts has been very notably increased as compared with that of the same parts in steel.

(*b*) *Special Grey Cast Irons Chill-Cast.* The case of heavy-oil motor injection pump tappets is particularly interesting, these being fairly light parts previously made in case-hardened alloy steel. Face A (Fig. 2) is in contact with the camshaft and must have a minimum hardness of 60 Rockwell C. Face B takes the pressure of the piston and must be as hard as possible. As for the peripheral surface, this has to be machined to very close limits and has a milled groove (C) so that it is essential that the wall metal must be easily machinable. The problem has been solved by the use of a nickel-chrome cast iron containing about 2.5 to 3.0 nickel, and from 0.3 to 0.6 per cent. chrome, the alloy content being balanced in relation to the carbon and silicon contents.

Hard Wear-resisting Cast Irons

Face A is chill-quenched, which allows of regular hardness of 65 to 68 Rockwell C being obtained (Brinell over 650). It had been proposed to flame harden face B, but it was found that, owing to its contact with the chill on face A, the metal reached face B slightly mottled, which without any treatment gives a Brinell hardness over 450 in the cast state. By special skilful casting devices, the hardness of the peripheral wall is kept below 300 Brinell with the metal perfectly grey, despite the fact that the wall is comparatively thin. It is noteworthy that the service life of these parts is very appreciably longer than with similar parts in case-hardened and quenched steel.

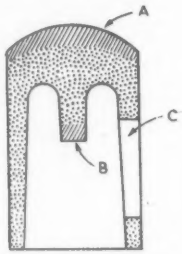

FIG. 2. — AN INTERESTING EXAMPLE OF CHILL-CAST GREY IRON.

Trials have recently been made with plates intended for the manufacture of locomotive slide bars. Many metals have been tried for this purpose, where the parts are subject to abrasive wear In two tests, components are rubbed against one another, under conditions of pressure and speed corresponding to working conditions, with high silica quarry sand introduced between the plates. Amongst the many steels and irons tested, the best results were obtained when manganese steel (12 to 14 per cent. Mn) was run in contact with chill-quenched nickel-chrome cast iron, which had a hardness of the order of 700 Brinell on the rubbing face.

(c) *Chill cast irons, completely white.*—For pins in crushers for pulverising coal in power stations, very good results have been obtained with a chill-cast nickel-chrome cast iron. In this case the chill is solely for the purpose of increasing the hardness, and especially to secure crystallisation oriented on lines perpendicular to the wearing surfaces. The cast iron used, normally white as cast, contains:—T.C, 3.5 to 3.8; Si, 1.0; Mn, 1.0; Ni, 3.0 to 3.2; Cr, 1.8 to 2.2, and P, 0.25 per cent. The Brinell hardness on the component in the cast condition is between 700 and 800.

As iron carbide is less corrodible than pearlite, white cast irons have a better resistance to corrosion than grey cast iron, but it is not generally known that considerable improvement can be made by the help of special additions which change the pearlite into austenite. This improved resistance to corrosion, for a given hardness, may be of definite interest in special cases of wear in which the parts are in a corrosive medium.

Here is an example to illustrate this point, showing a comparison between two white cast irons of practically equal hardness.

	Chemical Composition					Vickers Hardness, 50 kg. load 12 mm. (½ in.) test-piece.	Loss of Weight gr./m.²/hour in H_2SO_4 10 per cent. vol.
	T.C.	Si.	Mn.	Ni.	Cr.		
A	3.69	0.33	0.61	—	—	516	0.90
B	3.32	0.79	0.60	8.75	4.93	521	0.17

Austenitic white irons have been used with success for discharging components and in connection with clinker furnaces. They are subjected to wear at elevated temperatures of the order of 700 to 900 deg.

Various considerations emphasise the need for a cast material which shall be machinable, with a hardness approaching that of white cast irons but less brittle than grey or white irons. Cast steel, heat-treated, meets these requirements, if the carbon content be high enough. A carbon steel is sufficient for simple parts, but it becomes very difficult to quench it without cracks if there are any large variations in section. The Authors have been induced to look for a grade of steel which would harden by oil- or air-quenching, and would be easy to machine and to treat. The basic composition is:—C, 0.6 to 0.8; Mn, 0.8 to 1.2; Si, 0.25 to 0.50; Ni, 1.8 to 2.5, and Cr, 1.8 to 2.5 per cent.

As there is little information on cast steels of this type, below are given some results obtained during the Authors' experiments in bringing this question to a successful solution. The comparison of the three steels below shows clearly the influence of composition on susceptibility to quenching. These steels were made in crucibles in a heavy-oil-fired furnace.

	A.	B.	C.
C	0.82	0.57	0.57
Si	0.60	0.30	0.30
Mn	0.97	0.54	0.54
Ni	0.10	1.68	3.27
Cr	1.80	2.01	2.05
Brinell hardness 3,000/10, tungsten carbide ball on 50-mm. cubes.			
As-cast	309	305	460
Tempered at 850 deg. C., cooled in furnace (3.6 deg. per min. from 750 to 350 deg. C.)	248	280	311
Tempered at 800 deg. C., 20 mins. at temp., cooled from 800 to 500 at 1 deg. per min., then in air	226	221	262
Reheated to 625 to 650 deg. C., 30 mins., from cast condition	305	296	338
*Oil quenched from 800 deg. C.	695	610	590
,, ,, 850 ,,	707	700	605
,, ,, 900 ,,	707	695	642
*Air hardened from 800 deg. C.	283	275	524
,, ,, 850 ,,	288	507	582
,, ,, 900 ,,	327	617	620
Transformation point taken on Chevenard Recording Dilatometer.			
on heating, deg. C.	810	825	830
on cooling, start	700	710	315
finish	650	630	(?)

* Held at temperature for 30 min. before quenching.

Steels B and C can be softened to hardness ranging from 220 to 265, which allows of easy machining, and can then be hardened to 600 to 620 Brinell by air-hardening, whereas steel A does not harden appreciably under these conditions. Tests also showed that oil quenching often caused cracks even on fairly simple shapes, such as cubes.

The Authors compared the resistance to static deflection of white cast irons and a steel of the following composition:—C, 0.67; Si, 0.55; Mn, 1.05; Ni, 2.48; Cr, 2.08; S and P, 0.04 per cent. max. Transverse tests were made on 12 mm. diameter (½ in.) test pieces broken on an Amsler machine with 60 mm. between supports (2⅜ in.).

	Transverse Load (kgs.)	Brinell No. 3,000/10. W_2C Ball.
Air hardened from 825 deg. (20 mins. at temperature) ..	1,675 (3,685 lb.) to 1,780 (3,916 lb.)	573 to 591
Air hardened from 825 deg. (20 mins. at temperature), then annealed at 200 deg., 1 hr.	1,770 (3,894 lb.) to 1,930 (4,246 lb.)	527 to 555

White cast irons of the same hardness give very much lower transverse load values. The figures in the following table are taken from a previous Paper already mentioned. They show that it is essential to obtain a structure, consisting of carbide plus austenite in order to get deflection breaking loads of 1,000 kgs. (1 ton) with a definitely lower hardness value.

Chemical Composition.					Structure.	Brinell No. 3,000/10. W_2C ball 10 mm. thick test.	Total Load Bend Break in kgs.
T.C.	Si.	Mn.	Ni.	Cr.			
2.90	0.48	0.36	0.30	0.11	Carbide and pearlite ..	454	485 (1,067 lb.)
2.90	0.48	0.36	1.71	0.62	Carbide and sorbite ..	507	530 (1,166 lb.)
2.90	0.48	0.36	3.07	1.14	Carbide and martensite ..	566	672 (1,478 lb.)
2.90	0.48	0.36	4.35	1.70	Carbide and martensite and austenite	491	775 (1,705 lb.)
2.90	0.48	0.36	6.92	3.07	Carbide and austenite ..	389	810 (1,782 lb.) to 1,010 (2,222 lb.)

The following are the Brinell hardnesses obtained on various components, in the cast state-cast in steel D (with tungsten carbide ball of 10 mm. diameter, load 3,000 kgs.).

Plough shares	590 to 621
Plough flanges	586 to 610
Crusher parts	582 to 637
Cubes, 50 mm. sides (2 in.)	573 to 637
Cubes, 100 mm. sides (4 in.)	321 to 335
Prism-shaped test-pieces (18 mm. to 30 mm. × 120 × 120 mm. (¾ in. to 1¼ in. × 4¾ in. × 4¾ in.) ..	573 to 595
Ring, 120 mm. (4¾ in.) outside diameter, 65 mm. (2 9/16 in.) inside diameter, 65 mm. wide	192 to 228

A Few Practical Notes

Extra hard nickel chromic cast steel can be made either in the open hearth furnace (Siemens-Martin or electric, for example), or in crucibles, or even in the side blown converter. Their composition has been specially studied so as to allow of direct production in the converter by the addition, to a killed semi-hard steel of normal grade, of ferro-chrome and ferro-manganese with very high carbon content (8 to 10 per cent). The operation can then be continued as for a semi-hard steel with final additions of 3.5 to 4 per cent. C), and of about 1 per cent. of ferro-manganese (with 75 per cent. approximately Mn, and 6 to 10 per cent. of ferro-chrome (60 per cent. Cr and 8 to 10 per cent. C.).

Production in the electric furnace does not present any difficulty, the operation being performed exactly as for a semi-hard steel with final additions of high carburised ferro-chrome and ferro-manganese. For production in crucible furnace, it is preferable to obtain direct the carbon content required, which helps melting, and to add the ferro-chrome in a form containing very much lower carbon (circa 2 per cent.), and ferro-manganese of normal grade (75 per cent. Mn, and 6 per cent. C.).

Owing to the chrome content of these steels, the surface is covered, in the liquid state, with a film of chrome oxide, which gives them an appearance of a cold and slow-flowing metal. This fact must be taken into account in order to avoid over-heating, which would lead to getting a gassy metal which would be difficult to kill.

These steels cast satisfactorily, provided that the carbon is as stated, but it is advisable, especially with thin castings, to allow for moulds and cores with adequate compressibility to allow of easy shrinkage. As the critical quenching rate of these steels is very low, thin castings may become chilled in the mould and turn out hard and brittle in the cast condition.

According to the conditions, the castings can be used either in the as-cast state (thin castings), preferably after annealing at 200 to 300 deg. C., or, after air hardening; for large castings which are not sufficiently hard when taken from the mould, or after a more complex treatment comprising a homogenising treatment with fairly slow cooling, to allow of machining, followed by quenching and tempering.

After the usual treatment of cast steels, normalising for 4 to 6 hrs. at 900 to 950 deg. C,, followed by cooling in the furnace, quenching at 850 deg. and tempering at 650 deg., the following mechanical tests can be obtained:—

Tensile strength	105 kg./mm.² (67 tons)
Yield point	95 kg./mm.² (60 tons)
Elongation per cent. on $l = \sqrt{\frac{200}{3s}}\, s$	
Reduction of area	9 per cent.
Impact (Mesnager test KM)	0.6 kgm./cm.² (43 ft. lb.)
Brinell hardness	295

E

Hard Wear-resisting Cast Irons

After air-hardening from 850 to 900 deg. C., the Brinell hardness of such a steel increases to 600 to 660, according to the thickness of the castings, which regulates the rate of cooling. The steel then becomes a little more brittle, its Mesnager resilience falling to 0.3 to 0.5 kgm./cm^2 (22 to 36 ft.-lb.).

These steels are fairly easy to machine after the normalising treatment, provided the rate of cooling in the furnace has been sufficiently slow (rate less than 100 deg. per hr.). After this treatment the Brinell hardness is between 260 and 300, which is soft enough to allow of all the usual machining operations.

The maximum softening is obtained by reheating with cooling carried out in stages, as follows:—

(1) Heat at 700 deg. C. for ½ hr., cool slowly in furnace to 600 deg. C.

(2) Hold at 650 deg. C. for about ½ hr., then cool slowly to 600 deg.

(3) Hold at 600 deg. for about ½ hour, followed by fairly slow cooling to room temperature.

Such treatment will be necessary only in those cases where the nickel, chrome, and manganese contents, either separately or conjointly, are very high, but it will not be necessary when the composition falls within the limits given above. Oil quenching of these steels is not advisable, any more than it is for air-hardening steels of normal grade, as such quenching produces cracks.

It is necessary to take precautions during the tempering or the softening anneal treatment, so as to avoid cracks which might be caused in the metal if it were heated too suddenly. (Severe local stresses might be caused which, added to the internal stresses in the casting, might lead to fractures.) These steels can be used in all cases involving wear from erosion or abrasion: crushing apparatus, mechanical transport machines: pump parts dealing with impure water (mines or sugar factory pumps); parts of agricultural machinery (plough shares, harrow tines, excavator jaws, etc.), and where the parts are not subject to severe impacts requiring a high toughness, but where something is required better than cast iron for standing up to shocks and to static bending pressures.

As an example, parts for coke crushers are cited. For the manufacture of toothed rollers for coke crushing, an extra-hard nickel-chrome steel is being used at present, this being of the following composition:—C, 0.7 to 0.8; Si, 0.3 to 0.5; Mn, 1.2 to 1.5; Ni, 2.0 to 2.5; and Cr, 2.0 to 2.5 per cent.

These parts are used after a complete heat-treatment, namely: (*a*) tempering at 600 to 650 deg. C. to allow of machining; (*b*) air hardening from 900 deg. C., and (*c*) annealing to 200 to 250 deg. C. After this treatment, the rollers (parts of ⅜ in. to 1 5/16 in. thickness, weighing about 22 lb.), have a Brinell hardness of the order of 600.

Another interesting use of extra-hard cast steel is for the lining of crushers for pulverising metals. These lining plates (¼ to 1¼ in.) are given the same treatment as the rollers mentioned above and their hardness is of the same order. It was a question of replacing liners previously made of manganese steel, which, owing to wear on their surfaces, were introducing into the metal powders a quantity of manganese which was not acceptable for certain applications.

Flame Hardening and Surface Treatment

For a long time past consideration has been given to the question of depositing on the surfaces of cast iron or steel parts, particularly subject to wear, special coatings of alloy, by the oxyacetylene flame, or are put on so as to give a fairly thin deposit and thus improve appreciably the local resistance to wear. The first alloys used for this purpose were complex ones,

FIG.3.—ZONE OF TRANSITION-STEEL TO SPECIAL WHITE IRON PUT ON BY THE OXY-ACETYLENE FLAME ETCHED HNO_3 IN 4 PER CENT. ALCOHOL. (×80).

chrome-cobalt-tungsten with additions of silicon, manganese or titanium to facilitate the welding operation and to give a perfectly sound deposit, without used coated electrodes. The Authors considered that it should be possible to extend this method and to use, as the applied alloy, either alloy steels, or white cast iron or non-ferrous alloys[5].

It is possible to obtain, with alloy white irons of suitably controlled chemical composition, adjusted to the method of deposition (flame or arc), surface coatings with a Brinell hardness as high as 700 to 750, this considerably exceeding the hardness of the chrome-cobalt-tungsten alloys above-mentioned. The micrograph Fig. 3 shows the transition zone, steel to weld metal, of a

deposit of special white iron on a steel base. The coating is perfectly adherent, as the micrograph shows and as has been proved in numerous applications. Amongst the most interesting of these the Authors quote knife-edge guides on centreless grinding machines which were previously Stellited and of which the working face was strengthened by brazing-on a layer of tungsten carbide. Oxy-acetylene deposits have enabled the difficult problem of thin knife-edges to be solved, and their behaviour in service has been excellent for many years past in a very large number of applications. It should be pointed out also that deposits of white alloy irons for repairing worn parts (plough shares, harrow tines, etc.) had been successfully used.

When it is a question of getting at the same time good resistance to corrosion, a high hot-hardness and also good bearing properties, where lubrication is scanty or even impossible, the use of cupro-nickels, with tin base and silicon, makes it possible to get deposits of which the Brinell hardness can be controlled by regulating the chemical analysis of the welding electrodes, between 250 and 450. Up to Brinell hardness of 320 to 340, these deposits can be machined in the usual way, provided that tungsten carbide tools are used. Above that hardness machining is impossible, so that grinding is necessary with abrasives of suitable composition. A particularly important application of this type of deposit is for heated steam valve and cock seatings.

More recently, new alloys have been used for this surface deposit and coating, particularly hard nickel-chrome steels as previously described. These steels allow of a coating being applied which is machinable after tempering at 600 to 650 deg. C. After air-hardening the whole of the component, a hardness of 600 to 650 Brinell is obtained. It has thus been possible to repair by building up again stamping and pressing dies which showed so much wear on their working faces that it would otherwise have been necessary to scrap them. Other applications have also been made with chrome-tungsten-vanadium high-speed steels and even with chrome-cobalt-vanadium steels for cutting-tools. This has meant a great saving in lathe and planer tools at a time when tungsten and molybdenum were very scarce.

CONCLUSIONS

In this short Paper the Authors have tried to classify, and to describe briefly, various solutions which are available to the metallurgist in the problem of obtaining a hard cast iron, resistant to wear. They have also examined in some details the properties of a steel studied as a complement to the range of grey and white irons reviewed. They have deliberately omitted the processes of surface hardening, such as nitriding and local heating by the flame or by high frequency current, despite their definite interest, and have summarised a few ideas and test results from research work on surface-renewal by welding with cast irons or hard steels.

In order not to overload this Paper, the Authors have quoted only a few examples of applications. There are many others. They are in no doubt whatever that the possibilities offered by cast irons, in the campaign against wear, will be more and more used as they become better known.

REFERENCES.

The Authors quote particularly the following fundamental French works which have advanced the knowledge of cast irons.

1 A. PORTEVIN. "L'essai de dureté à la bille sur le fonte aciérée" (Congres de Fonderie de Liége, September, 1921).

"Microstructure des fontes aciérées." *Revue de Metallurgie*, 1922, vol. XIX, p. 227.

"Les essais mécaniques des fontes" (Conférence faite à l'Association Suisse de Fonderie, Zurich, December, 1926).

"Les fontes résistantes: examen des facteurs élémentaires du problème" (Conférence à l'Association Technique de Fonderie, March, 1927).

"Caractérisation des propriétés mécaniques des pièces moulées en fonte grise" (Congrès de l'Association Internationale des Méthodes d'Essais des Matériaux, Zurich, September, 1931).

A. PORTEVIN and LEMOINE. "Quelques remarques pratiques sur la fabrication actuelle des fontes résistantes" (Congrès International de Fonderie de Bruxelles, September, 1935—Mémoire du Congres, p. 267).

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"La fonte et le four électrique." *La Fonte*, no. 20, p. 757.

"Sur quelques modifications physicochimiques des fontes dites perlitiques." Mémoire au Congrès International de Liége, June, 1930.

2 L. GUILLET, J. GALIBOURG and M. BALLAY. "Sur les points critiques et la trempe martensitique des fontes au nickel-chrome." *Comptes Rendus*, 1928, vol. 187, p. 14.

"Sur le traitement thermique durcissant des fontes grises." *Comptes Rendus*, 1930, vol. 191, p. 538.

"Recherches syr la trempe martensitique et le traitement thermique durcissant des fontes." *Revue de Metallurgie*, 1931, p. 581.

3 DELBART AND LECOEUVRE. "Etude de quelques propriétés physiques d'une fonte austenitique au nickel-manganese à basse teneur en carbone" Bulletin de l'Association Technique de Fonderie, 1934, p. 279.

DELBART. "Etude d'une application industrielle de la transformation martensitique des fontes austénitique." *Revue du Nickel*, October, 1935, p. 207.

4 Voir M. Ballay and R. Chavy. "Les fontes blanches spéciales. Recherches sur les propriétés de quelques fontes blanches au nickel-chrome." Communication au Congrès International de Fonderie de Bruxelles, September, 1935.

INSTITUTE OF METALS

The annual luncheon of the Institute of Metals was held on September 12 at the Connaught Rooms, London, W.C.2. Col. P. G. J. Gueterbock was in the chair. Speeches were made by the Hon. R. M. Preston (past-president), Capt. the Right Hon. Oliver Lyttelton, M.P., and Sir Charles Darwin, F.R.S. Amongst those present prominent in the foundry industry were:—

Prof. L. Aitchison, Mr. G. L. Bailey (Director, British Non-ferrous Metals Research Association), Mr. D. F. Campbell, Dr. W. F. Chubb, Mr. H. W. Clarke (president, British Non-ferrous Metals Federation, and president, Aluminium Development Association), Mr. V. C. Faulkner (Editor, FOUNDRY TRADE JOURNAL), Sir William Griffiths, Mr. Freeman Horn, Sir William Larke, Mr. A. J. Murphy, Dr. L. B. Pfeil (member of the council of the Institute of Metals), Prof. T. Turner (past-president) Mr. H. G. Warrington, Dr. E. G. West, and Mr. D. Howard Wood (president, Institute of British Foundrymen).

GERMAN NON-FERROUS (COPPER-BASE) FOUNDRY INDUSTRY*

REVIEW OF THE RECENT INVESTIGATION

This report describes in considerable detail the results of the investigation of 18 German non-ferrous firms. It is noteworthy that in one of these foundries had mechanisation been adopted to any major extent, while there appeared to have been little attempt to instal scientific sand conditioning plant. In these respects the German non-ferrous sand foundry industry was definitely behind British or American standards.

The most striking feature brought out by the report is the widespread development throughout Germany of methods of manufacture of "combined" castings, *i.e.*, steel-backed bushes or bearings lined with brasses, gunmetals, or lead-bronzes. This development had undoubtedly been dictated by shortage of raw materials, primarily of copper, nickel and tin, the manufacture of bronze backed bearings and bushes, and of solid bronze gears, having been prohibited by the German government in 1937. Static and centrifugal methods of casting were in general use, and while such methods are well known in both the U.K. and U.S.A., the scale of plant installed, and the dimensions of the "combined" components manufactured, were probably greater than in either of these countries. The "diffusion method," developed by the Braunschweiger Huttenwerk, and adopted by other German firms, and its application to the manufacture of bronze-lined gears, worms, etc., on a large scale, was particularly interesting. Lead-bronze lined bearings and bushes, some of a most massive size, were also manufactured by this process.

Bronze Lining of Gear-teeth

The experimental work at V.D.M. Heddernheim, Frankfort/Main, on the bronze lining of gear-teeth, by copper-plating followed by reaction with stannous chloride vapour to form tin-bronze at the reacting surfaces, affords a further interesting commentary on the German efforts to conserve materials. Actually three large plants for commercial production by this method were projected.

Other items of interest were the centrifugal casting plants at the Osnabrücker Kupfer and Drahtwerke, the largest machines being capable of casting cylinders up to 1,600 mm. and 12 metres long, weighing up to 16 tons, while batteries of smaller machines were installed for casting cylinders from 40 mm. o.d. up to 400 mm. o.d. The Osnabrück patented method of lining the dies with thin sheet copper prior to casting is also described.

Gravity die-casting of copper-base alloys by Piel and Adey, Solingen, with details of die-pressing technique, is dealt with at some length. The "Niporit" feeding flux and the Busselmann semi-permanent mould material used by Ostermann, Cologne, during the war, are of some technical importance, and further details are being obtained. The casting of copper tuyeres at Hundt and Weber, Siegen, is described in detail, this process being of considerable interest to manufacturers in Great Britain, while the manufacture of forged tuyeres by Dango and Dienenthal, Siegen, is also covered. As regards alloy compositions, nothing of outstanding interest was seen. The Germans did not appear to be so advanced as this country or America in the development of aluminium- or manganese-bronzes, while the leaded gunmetals and lead-bronzes were of quite orthodox type.

P. T. HOLLIGAN.

CORRESPONDENCE

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

To the Editor of the FOUNDRY TRADE JOURNAL.

CORROSION OF CASTINGS

SIR,—I should like to congratulate you on the leader in the FOUNDRY TRADE JOURNAL, dated August 29, 1946. For some considerable time I have held the view, and expressed it, that it would be of greater value to industry if efforts were made to produce a cast iron readily machinable which had greater resistance to corrosion and abrasion than concentrating on increasing the strength of cast iron. Most of the work carried out by the various organisations seems to have been only on producing strong irons, but I am certain the engineering industry is equally, if not more, interested in other properties of cast iron. As you know, the firm with which I am connected are large manufacturers of centrifugal pumps and it is our custom before supplying a pump to ascertain by means of corrosion tests the most suitable metals to employ. Cast iron is always one of the metals tested. In fact, I have carried out fairly extensive tests on the corrosion of cast iron under various conditions, and developed the use of alloy irons in our products other than those used for the chemical industry. No doubt you are aware of the Paper, "Cast Iron in the Chemical and Process Industries," by F. L. La Que, published by the Gray Iron Founders' Association, of Washington. This is an excellent piece of work. Also there is in America a publication "Corrosion," which is the organ of the National Association of Corrosion Engineers. This gives a considerable amount of data on the corrosion of cast iron and other alloys.

I would strongly suggest that the research organisation of the industry should devote more time to this question of corrosion, and further, it might be worth while for the technical committee of the Institute of British Foundrymen to consider also this question.

Yours, etc.,

EDWARD J. L HOWARD.

Mather & Platt, Limited, Park Works,
Manchester, 10.

September 11, 1946.

* B.I.O.S. Final Report No. 296, Item No. 21.

ANNEALING RATE IN GASEOUS MALLEABLISING*

By D. M. DOVEY, M.A., and I. JENKINS, M.Sc., †

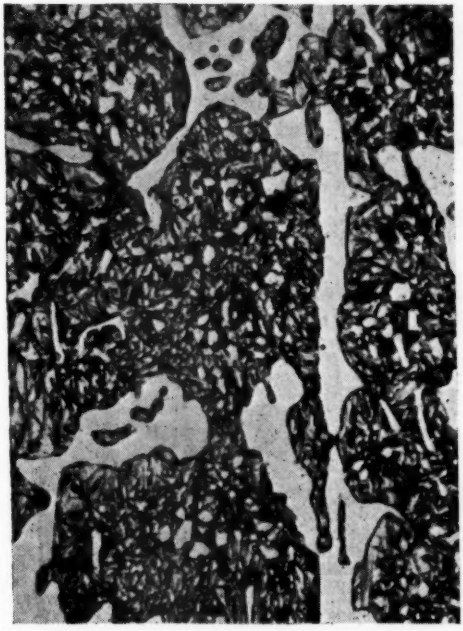
INTRODUCTION

The production of whiteheart malleable by the annealing of white cast iron involves both decarburisation and graphitisation of the casting. The extent to which both are allowed to proceed, at least from the point of view of malleability, is determined to a large extent by the section of the casting. Thus, with castings of very light section, complete decarburisation with the absence of free graphite is usually preferred, and this can be obtained readily within a reasonable annealing time. To obtain a comparable structure in a casting of heavier section, however, would necessitate a time treatment far too long to be economical. In such cases it is the practice to develop the typical structure of whiteheart malleable, containing laminated pearlite and spheroidal graphite, both of which decrease in concentration from the centre to the surface of the casting to give a carbon-free, ferritic rim. In this way the maximum combined carbon at any point within the casting is reduced to below the eutectoid composition of 0.83 per cent. carbon, the excess of carbon being present as graphite.

Generally speaking, the combined carbon at the centre of heavy castings malleablised in this way is near to the eutectoid composition, and since the carbon gradient from the centre to the surface of the casting is almost a linear function of the thickness, it will be seen that the mean residual carbon content of castings possessing the above structure will increase as the section of the casting increases. It is often the practice to assess the degree of malleability required in an iron of a particular composition, by the mean carbon content remaining after annealing, and to estimate by experience the time of annealing necessary to ensure this result. In this connection any simple relationship that can be established between the maximum section of a casting and the time of annealing necessary to give the required degree of malleability in that section—or, in other words, its mean residual carbon content—would appear to have some practical value.

The iron ore process of annealing does not lend itself very readily, however, to the development of a simple formula of this kind, since it involves too many unknown and variable factors. Thus for a simple derivation and application of a formula, it is necessary to know the actual temperature attained by the castings during annealing. This is not very readily determined in the ore annealing process and especially during the slow heating and cooling cycles, when the castings may be undergoing structural changes such as decarburisation and graphitisation, due allowance for which would have to be made in any formula such as that proposed. Further, it is necessary to have complete information on the rate at which carbon is being removed from the iron throughout the annealing treatment. Whilst it has now been definitely established that the basic decarburising reactions in the ore process are gaseous, and the composition of the atmosphere around the castings has been determined, it has also been shown that the composition of the atmosphere progressively changes as decarburisation proceeds, and it is extremely unlikely that the maximum rate of carbon removal is maintained throughout the annealing treatment.

Recent publications[1-4] have described processes for the production of whiteheart malleable by treatment of the castings in controlled atmospheres. In these new processes the actual temperature attained by the castings during annealing can be more readily and more accurately measured, than is the case in the ore annealing process. Also the heating and cooling



(A)—ANNEALED 1 HR.—1,000 DEG. C. SHOWING SMALL GRAPHITE NUCLEII. (x 500.)

* A Paper read before the 43rd annual conference of the Institute of British Foundrymen, Birmingham, June, 1946.

† Research Laboratories of the General Electric Company, Limited, Wembley, England.

Annealing Rate in Gaseous Malleablising

cycles, as compared with the ore process, are much shorter (excepting for specialised treatments), with the result that decarburisation and graphitisation are in the main confined to a narrow range of temperature near to that selected for annealing. Furthermore, since the composition of the annealing atmosphere is under close control, it is possible to maintain the maximum rate of decarburisation throughout the period of annealing. It seems possible, therefore, that the new gaseous process of producing whiteheart malleable will permit of the application of a formula relating the time of annealing, the mean residual carbon content of the annealed iron, and the thickness of the casting.

Application of Diffusion Laws

It has been shown[3] that the decarburisation of white cast iron may involve a number of processes which may be proceeding simultaneously in the casting. They can be listed as follow:—(a) Oxidation of the carbon at the surface of the casting. (b) Diffusion of carbon from the body of the casting to the surface, to replace that which is oxidised. (c) Solution of excess cementite to maintain the saturation solubility of austenite for carbon. (d) Graphitisation. (e) Re-solution of graphite in areas where all the primary cementite has been removed and where the carbon in the austenite is below the saturation solubility with respect to graphite.

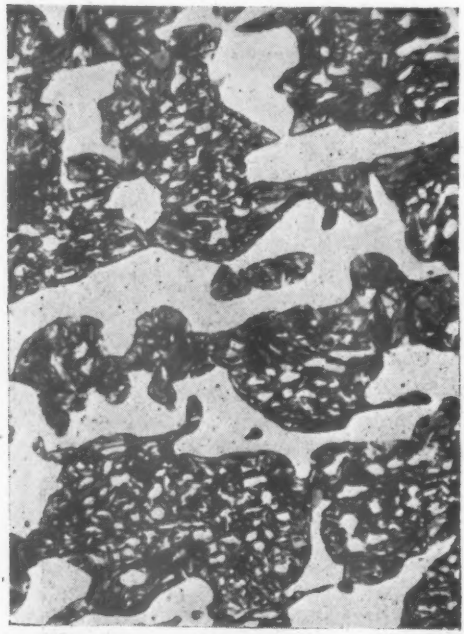
Assuming that the annealing atmosphere always removes the carbon from the surface of the iron as fast as it arrives, the extent of decarburisation is controlled by the rate of diffusion of carbon in the casting. The rate of diffusion of a solute in a solvent—in this case carbon in iron—is governed by Fick's Law of linear diffusion:—

$$\frac{ds}{dt} = \Delta \frac{dc}{dx}$$

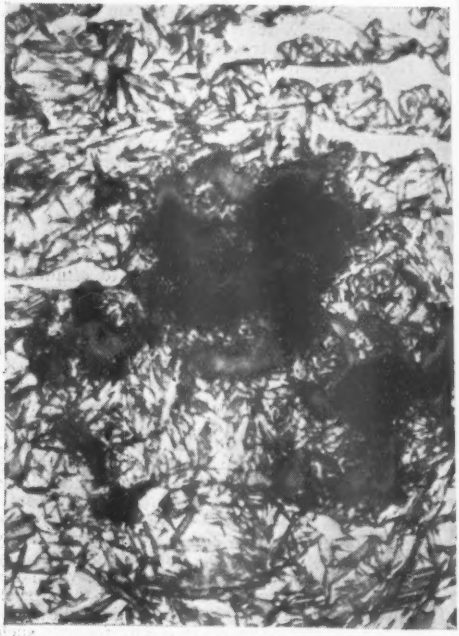
where $\frac{ds}{dt}$ = quantity of solute diffusing in time dt

$\frac{dc}{dx}$ = concentration gradient of the solute

Δ = the diffusivity constant.



(B)—Annealed 2 Hrs.—1,000 deg. C. Showing Complete Absence of Graphite Nuclei. (x 500.)



(C)—Annealed 4 Hrs.—1,000, deg. C. Graphitisation Well Advanced. (x 500.)

Fig. 1.—Graphitisation in White Cast Iron. C, 3.02; Si, 0.55; Mn, 0.30, S, 0.103, and P, 0.07 per cent.

Various solutions of the above equation have been applied in the literature on gaseous malleablising, and by this means it has been possible to relate the diffusivity constant with "experimentally-determined" values for the mean residual carbon content, thickness of casting and time of treatment. Thus, for example, Baukloh[1] [2] and Robiette[4] refer to equations of this type, the former deriving values for the diffusion constant of carbon in austenite which, however, do not agree very well with those determined by other workers on iron-carbon alloys of greater purity and somewhat lower initial carbon content.

The application of standard diffusion equations cannot be indiscriminate, however, especially in systems where the rate of diffusion of the solute may be influenced considerably by other processes proceeding simultaneously within the system. Thus, in a previous Paper[3] by one of the Authors, use was made of the following expression put forward by Ransley.[5]

$$K = \frac{W^2}{2\,C_0\,St.}$$

where K = diffusivity constant (cm.²/sec.).

W = total weight of carbon diffused per unit area of surface (gms./cm.²).

C_0 = initial concentration of carbon (gms./cc.).

S = saturation solubility of the carbon at the temperature considered (gms./cc.).

t = time of treatment in seconds.

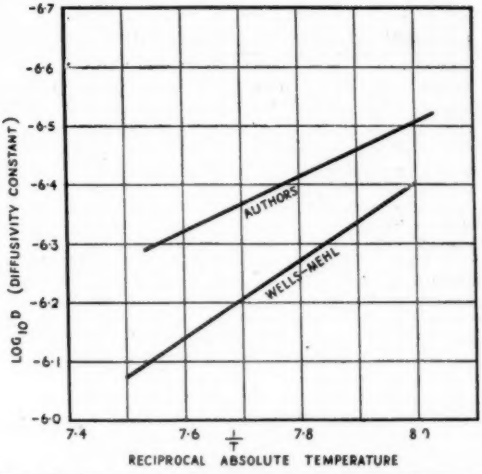


FIG. 2.—EFFECT OF TEMPERATURE ON THE DIFFUSION CONSTANT OF CARBON IN IRON.

It was shown that for a casting of given thickness, at a given temperature, the value of $\frac{W^2}{t}$ falls off with increasing time of anneal, and thus an equation of this simple type is not applicable to the particular annealing process. Therefore, during the annealing of white cast iron, there are a number of factors which may conceivably interfere with the diffusion of carbon to the surface. The presence in solid solution in the iron of other elements such as silicon, phosphorus, manganese, etc., and second-phase constituents such as cementite, for example, may obstruct the diffusion of carbon, whilst it has already been demonstrated by Bramley and colleagues[6] that non-metallic inclusions of oxides, sulphides and phosphides may have a considerable retarding effect.

During the early stages of the annealing process the diffusion of carbon to the surface of the casting is maintained by the solution of the primary cementite. In high sulphur irons it is generally accepted that the solution of primary cementite during decarburisation is retarded by a film of iron sulphide. A similar inhibition

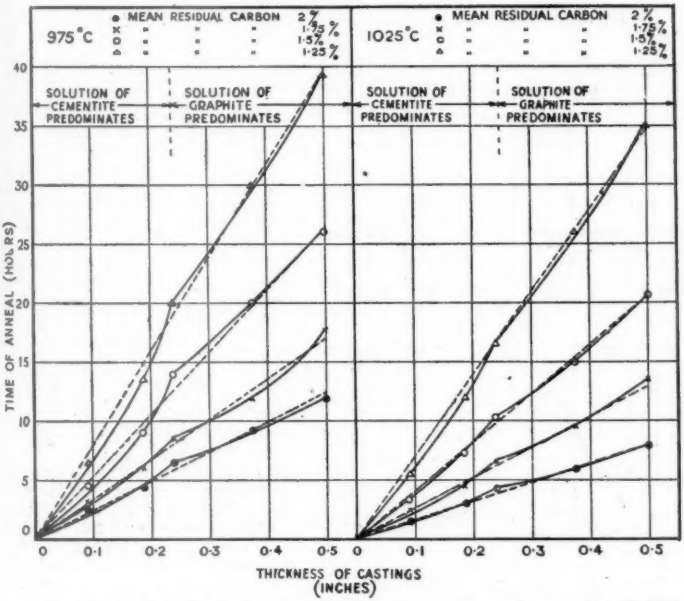


FIG. 4.—DOUBLE PARABOLIC NATURE OF TIME-CASTING-THICKNESS CURVES.

Annealing Rate in Gaseous Malleablising

effect has been observed, however, in irons containing a high manganese-sulphur ratio, as shown in Fig. 1. As will be seen, small graphite nuclei have formed early in the annealing treatment, but with continued annealing and decarburisation the graphite has re-dissolved, presumably to maintain the maximum solubility of carbon in the austenite, whilst the primary cementite still remains as a separate phase and shows no indication of having entered into solution. With continued decarburisation, the primary cementite eventually commences to dissolve in the austenite and graphitisation proceeds in the usual manner. This effect can be accounted for by the presence around the cementite of an inhibiting film which is removed only after decarburisation has proceeded to some degree.

Finally, as pointed out in the previous Paper,[3] the precipitation from and the re-solution of graphite in austenite must also have a marked effect upon the amount of carbon diffusing to the surface. Thus in any system in which any or all of the foregoing factors may be playing a major part, it is not possible to relate known values for the diffusion of carbon in pure austenite to experimentally determined values of residual carbon content, thickness of casting and annealing time. Neither can such experimental data be used for the determination of the diffusivity constant of carbon in pure austenite. The results quoted by Baukloh, for example, show at any given temperature a spread in the values of the diffusion constant comparable with that arising from an increase in the annealing temperature of 50 deg. C. Further, in view of the variety of factors which may have a bearing on the decarburisation of white iron during annealing, the application to malleablising of data on the diffusion of carbon in pure austenite, even comparatively as suggested by Robiette, may be misleading.

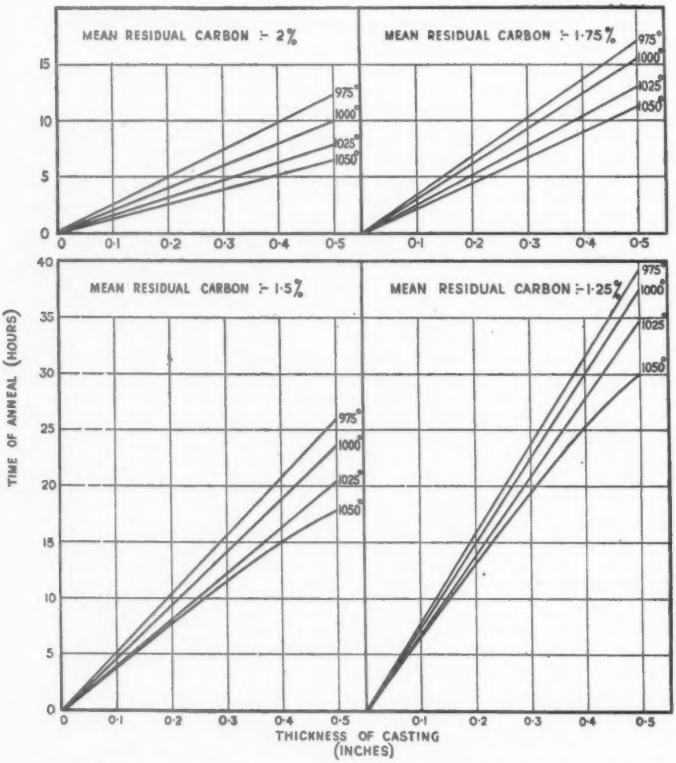


FIG. 3.—RELATIONSHIP BETWEEN ANNEALING TIME AND THICKNESS OF CASTING.

In the results reported in the previous Paper, it was found that the values for $\frac{W^2}{t}$ remained reasonably constant over a period of time at the commencement of the anneal. This period decreased with increasing annealing temperature, and corresponded approximately to the time prior to that at which the graphitisation became very pronounced. The data appertaining to these initial periods of the anneal at the various temperatures may therefore be used to determine the diffusivity constant of carbon in austenite for the particular white iron used in the experiments. The diffusion equation put forward by Ransley, referred to above, was used, and the results are shown in Table I, together with the values reported by Wells and Mehl,[7] and by Baukloh. It was considered that at any temperature the true value for the diffusivity constant of carbon in austenite is more nearly approached during the initial period wherein the value remains consistent (*i.e.*, the values of D in Table I which are not bracketed are considered to be near to the true values).

A plot of the logarithm of the diffusivity constant against the reciprocal of the absolute temperature should give a straight line, and as shown in Fig. 2, this relationship holds for the initial values obtained at 975, 1,000 and 1,025 deg. C., whereas the initial value obtained at 1,050 deg. C. does not lie on the straight line, presumably because this value was obtained after graphitisation of the iron was well advanced. It should be noted that the values of the diffusivity constant given in Table I and Fig. 2 are for austenite saturated with carbon at the corresponding annealing temperature, since in all cases, excess primary cementite was still present in the iron afer annealing. For the purposes of the calculations, the values taken for the maximum carbon solubility in austenite at 975, 1,000, 1,025, and 1,050 deg. C. were 1.4, 1.46, 1.52, and 1.57 per cent. respectively.

Empirical Relationship between Thickness of Casting, Time of Anneal and Mean Residual Carbon Content

Curves relating the thickness of casting to the annealing time necessary to reduce the mean residual carbon content of the iron to a fixed value are shown in Fig. 3. These curves are derived from the results reported in the previous communication.[3] It will be noted that there is not a wide divergence from a straight line relationship between time and thickness of casting, excepting at the maximum annealing temperature used in the investigation, *i.e.*, 1,050 deg. C. The curves for 1,050 deg. C. show an increasing departure from a straight line relationship as the carbon content of the annealed iron decreases. Further, the curves at all temperatures show a departure from a straight line relationship, more especially in the thinner sections and for residual carbon contents of 1 per cent. or less (Fig. 4). This divergence is of a similar type in all the curves, and cannot be ascribed to experimental error. Suggestions as to the factors which govern the relationship shown by the curves would be welcomed. It may be that the rate of removal of carbon is governed by, amongst others, two major conditions, namely, that in which cementite is going into solution and that in which graphite is going into solution to maintain the diffusion of the carbon to the surface.

The curves obtained cover the period during which the transition from one controlling condition to the other takes place. In view of the fact that, for the reduction of the mean carbon content to a fixed value, the weight of carbon oxidised per unit area of surface is directly proportional to the thickness of the casting, it follows that the relationship between time of anneal and thickness of casting should be parabolic when either of the controlling factors dominate the process. In other words $\frac{d^2}{t}$ is a constant, but has a

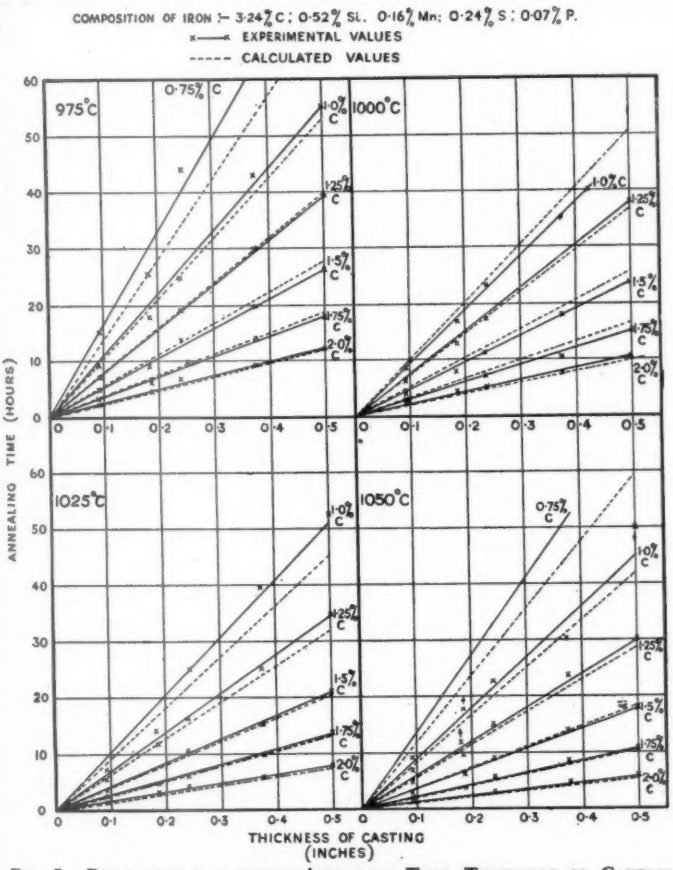


FIG. 5.—RELATIONSHIP BETWEEN ANNEALING TIME, THICKNESS OF CASTING AND MEAN RESIDUAL CARBON CONTENT.

Annealing Rate in Gaseous Malleablising

different value for the wholly cementitic and wholly graphitic conditions. If this is so, the straight line relationship shown in Fig. 3 is more accurately represented by the initial portions of two parabolas, as shown in Fig. 4. Furthermore, there is a danger in continuing the series of empirical straight line curves beyond the limits established in practice.

It should be noted that the above equation has been developed on the basis of the experimental work reported in the earlier Paper, which was limited to a specific iron composition, and covered a limited range of both annealing temperature and size of castings. It may be possible that a similar expression can be developed for irons of a composition different to that used in the present investigation, provided that during annealing the carbon diffusing to the surface of the iron is removed as fast as it arrives.

TABLE I.—*Diffusivity Constant for Carbon in Iron.*

Temperature, deg. C.	Thickness of Casting (d), in.	Time of Anneal (t), hrs.	Carbon Loss (W), Mgms. per cm².	Mean Residual Carbon Content, per cent. (C_R).	Diffusion Constant(D) (gs. per cm² per sec.).	D Wells and Mehl. 1 per cent. Carbon.	D Baukloh	
							C_R 1.0 per cent.	C_R 1.5 per cent.
975	0.5	5	0.018	2.42	3.1×10^{-7}	4.0×10^{-7}		
		10	0.025	2.09	2.99×10^{-7}			
		15	0.031	1.83	3.06×10^{-7}			
		20	0.035	1.70	2.93×10^{-7}			
		25	0.039	1.55	2.91×10^{-7}			
1,000	0.5	5	0.020	2.34	3.66×10^{-7}	4.9×10^{-7}	2.84×10^{-7}	2.88×10^{-7}
		10	0.029	1.96	3.75×10^{-7}			
		15	0.033	1.74	$(3.33) \times 10^{-7}$			
1,025	0.5	5	0.022	2.22	4.24×10^{-7}	6.14×10^{-7}		
		10	0.029	1.85	$(3.69) \times 10^{-7}$			
		15	0.033	1.67	$(3.18) \times 10^{-7}$			
1,050	0.5	5	0.023	2.20	$(4.51) \times 10^{-7}$	7.80×10^{-7}	4.54×10^{-7}	5.27×10^{-7}
		10	0.030	1·87	$(3.83) \times 10^{-7}$			
		15	0.035	1.59	$(3.47) \times 10^{-7}$			

It is considered that the portion of the curve covering the period during which the solution of cementite predominates will always approximate to a straight line, as shown in Fig. 4. However, beyond this point the time of anneal and the thickness of casting are considered to be mainly governed by a parabola resulting from the re-solution of graphite. Hence, as the thickness increases beyond the range covered by the curves, the true relationship between annealing time and thickness will be a continuation of this parabola, and hence will progressively deviate from the empirical straight line.

For a given temperature a relationship of the type

$$t = Ad\,(C_O - C_R)^x$$

will conform fairly closely to the experimental curves shown in Fig. 3. where t = time of anneal in hours; d = thickness of casting in inches; C_o = percentage original carbon content; C_R = percentage mean residual carbon content; and A and x = empirical constants.

Fig. 5 gives the experimental curves, together with those derived empirically, using the values of A and x for the corresponding annealing temperature, as given in Table II.

TABLE II

Values for A and x in the equation $t = Ad\,(C_O - C_R)^x$, for castings up to 0.5 in. thick.

Temperature, deg. C.	A	x
975	14	2.50
1,000	11	2.75
1,025	8	3.00
1,050	6	3.25

REFERENCES

1 W. Baukloh, F. Schulte and H. Friederichs, Avchiv. für das Eisenhüttenwesen—16. March, 1943, pp. 341-54 (Iron and Steel Institute Translation Service No. 158).
2 W. Baukloh and A. K. Foroud, *Ibid.*—16. March, 1943, pp. 355-62 (Iron and Steel Institute Translation Service No. 165).
3 I. Jenkins and S. V. Williams, Institute of British Foundrymen. Advance Copy No. 824, 1945.
4 A. G. Robiette, *Ibid.* Advance Copy No. 825, 1945.
5 C. E. Ransley, J. Inst., Met., **65** (2), 1939, pp. 147-71.
6 A. Bramley and H. D. Lord, J. Iron and Steel Inst. Carnegie Scholarship Memoirs—**18**, 1929, pp. 1-29.
7 C. Wells and R. F. Mehl, American Institute of Mining and Metallurgical Engineers. Technical Publication No. 1180 Metals Technology —7 (5), 1940, pp. 1-28.

BOOK REVIEW

The Metallurgy of Steel Castings, by C. W. Briggs. Published by the McGraw-Hill Book Company, 330, West 42nd Street, New York. Price $6.50.

But few British foundrymen will have anything other than an academic interest in the earlier part of the first chapter, as it deals with basic open practice, a process not widely used for the production of steel castings in this country. The second half of the chapter, however, covers the basic electric process. Here is disclosed a practice not very commonly followed in this country, and that is the addition of high carbon Swedish-type pig-iron immediately after removal of the first slag. The system seems to have much merit. The one slag process is detailed for cases where low-phosphorus scrap is available.

Chapter II covers the acid open-hearth process, and even this is only of limited interest, as there are not very many firms who use this process; they are important ones, however. The acid electric furnace, too, has only limited application; but the next section, that of the acid convertor process, is the one which is widely used in Great Britain. It is, perhaps, on this account that the reviewer feels that this section would be improved by incorporating some of the latest British work on the subject, especially that of Fassotte.

Chapter III—"Gases, Deoxidation, Porosity and Inclusions"—is well worth careful study, especially as American pioneer work on this subject is presented insofar as it specially relates to steel castings. Next, there is a really practical section devoted to tapping and pouring. This is followed by a section covering the volume changes from the liquid state to room temperature. British readers will appreciate temperatures shown on the very clear graphs being given in both Centigrade and Fahrenheit.

The Author is at his best in a long chapter on the solidification of steel castings. Herein much of his own research work in conjunction with other well-known workers has been reduced to reasonable dimensions for logical presentation. "Gates and Risers" require over 50 pages for their consideration, yet no reference is made to the work of Jazwinski and his colleagues, the merit of which calls for its inclusion in future issues. With this exception it is the most complete study so far published.

Few people are better informed on hot-tear formation than the author, and his work, recapitulated and reinforced by the views of others, makes Chapter IX an outstanding contribution. The reviewer is generally not satisfied with sand research. It was not initiated from basic principles, yet he likes the treatment of the subject as presented by the author, who has managed to cover a very wide field in something over 50 pages. The final chapters cover the effect of molten steel on sands, cores, and washes, casting defects, fettling, heat-treatment, welding and inspection. Each chapter is furnished with a list of references—a system to be commended. As a reliable textbook on steel castings, this book has achieved a particularly high level, and should remain a standard work for many years to come.

DESIGN FOR MAGNESIUM CASTINGS

Mr. C. J. McDowell, in an article he wrote for "Product Engineering," states that in general, any part that can be cast in aluminium can be cast in magnesium, although the design must be modified to compensate for differences in the properties of the two metals. The low modulus of elasticity of magnesium, its softness, low fatigue strength, temperature sensitivity and different cooling characteristics must be taken into consideration.

One of the outstanding characteristics of magnesium is its low elastic modulus, which is 6,500,000 lb. per sq. in. as compared to 10,500,000 lb. per sq. in. for aluminium. This low elastic modulus, combined with high tensile strength, creates unusual design problems. Under straight tension a magnesium test specimen will be elongated almost twice as much as the same unit tensile stress as will aluminium, and more than four times as much as steel.

In addition to the low elastic modulus, special consideration must be given to the low shock resistance of magnesium as compared with aluminium. These two factors require that castings be designed with large fillet radii, about twice those that would be used for iron castings, and with generous tapers from heavier to lighter sections.

When magnesium solidifies and cools to 260 deg. C., it is still extremely plastic and retains that plasticity to a considerable degree down to a temperature of 93 to 149 deg. C. As a result the metal exerts little pressure upon cores and is prevented from contracting, so that it conforms to the mould dimensions by plastic flow.

FORTHCOMING EVENTS

(Secretaries are invited to send in notices of meetings, etc., for inclusion in this column.)

SEPTEMBER 26.

Royal Statistical Society—Industrial Applications Section (Sheffield group):—"What Statistics Can Do in Industry that Other Methods Cannot Do," by Mr. A. W. Swan. At the Royal Victoria Station Hotel, Sheffield, at 6.30 p.m.

OCTOBER 2.

Institute of Welding:—Presidential address. At the Institution of Civil Engineers, Great George Street, London, S.W.1, at 6.30 p.m.

OCTOBER 4.

Royal Statistical Society—Industrial Applications Section (London group):—"Statistics in America," by Mr. M. Milbourn. At the E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, London, W.C.2, at 6.30 p.m.

OCTOBER 7.

Society of Chemical Industry (London section):—"Chemical Research and Corrosion Control: Some Recent Contributions of a Corrosion Research Group." At the Chemical Society, Burlington House, Piccadilly, London, W.1, at 6.30 p.m.

OCTOBER 10.

Institute of Metals (London local section):—"The Purple Alloy of Gold and Aluminium," by Dr. J. H. Watson. At 4, Grosvenor Gardens, London, S.W.1, at 7 p.m.

Institute of British Foundrymen

SEPTEMBER 25.

London branch:—Presidential address. Discussion on work of technical sub-committees. At the Waldorf Hotel, London, W.C.2, at 7.30 p.m.

COMPRESSED AIR IN THE FOUNDRY

By "PNEUMATIC"

Compressed air is used extensively in many foundries for such operations as working large moulding machines, core blowers, pneumatic rammers, blow guns, chipping hammers, shot blast, lifting tackle, etc. There are still many foundries, however, that have not yet adopted this flexible form of power, and in these days, when skilled labour is in short supply, it may be wise to investigate the possibilities of compressed air for a number of operations which can be sucessfully performed by its aid.

When installing compressed air equipment a debatable point often arises as to the size of the compressor necessary. Some advocate one large compressor situated centrally in the works, whereas others prefer to have two or more smaller ones, either housed together, or in different parts of the plant. These smaller units can be used as and when required. If the latter scheme is adopted, it is more economical when only a comparatively small amount of air is required at particular times, such as, for example, if a number of men are working overtime on a particular mould which it is desired to complete with all speed. Then again, if a breakdown should occur, or the compressor needs overhauling, the other units could continue working and supply the foundry with a certain amount of air, whereas if only one large compressor was installed a stoppage of this nature would be a serious matter. In any case, it is not necessary to total up the air consumption of all the pneumatic tools in the foundry and obtain a compressor or compressors of equal capacity—unless an expansion in the use of air power is anticipated—as the tools are only used intermittently, and thus allow of a build up in the receiver. For such service it is generally recommended that a reasonable size compressor be installed (if necessary in duplicate), together with a large air receiver of ample capacity to act as a reservoir for any extra demands at peak periods of the day.

Location of Compressor

To obtain maximum results from pneumatic machinery a number of simple points must be carefully considered. For example, if the compressor be installed in an engine house in which the atmosphere is warm and this air is drawn into the compressor, the efficiency of the machine will be lower than if cold air is drawn in from outside the engine house. In the interest of fuel economy, it is recommended that the air inlet be situated either at the northern or eastern end of the building. As the climate of this country is humid it is inevitable that some moisture will be found in the compressed air, especially after the passage through the air pipes leading to the various parts of the shop, because in compressing the air is heated, and thus on cooling this moisture is condensed and forms water.

Both water and water vapour are detrimental to the best results in pneumatic tools, and should be removed before the air is used in them. This can be accomplished by the installation of an after-cooler, in which the air is cooled and the moisture condensed and drawn off before passing to the receiver. As a further safeguard, and in the case where no after-cooler is fitted, the air should enter the receiver at the bottom and be taken off to the various machines from the top. In this way, any condensation which takes place in the receiver can be readily drained off and not carried over into the pipe line.

Pipe Line Construction

The pipe line from the receiver should slope back toward this, so that should the air contain further moisture in suspension, and this is condensed in its passage through the pipe, it can drain back and not be carried to the tools.

In long pipe lines, water-traps are an added safeguard, and these can either be procured from manufacture of such equipment, or pieces of short pipe of large diameter can be inserted in the pipe line, at regular intervals and at right angles in a vertical direction, to the flow of air. Any condensed moisture can be drawn off in this manner quite easily. Then again, where hoses are taken from the main line, the connection should be to the top of the pipe by a suitable elbow, and not to the bottom, in this way only dry air enters the tools.

Air Filters

Not only must air be comparatively dry for best results, but it must be free from any foreign matter, consequently all air should be filtered before entering the compressor, to protect the valves and cylinder, and likewise filters should be placed in the air line near to the pneumatic tools to ensure that no foreign matter from the pipe line, like scale or rust, is carried into the working parts to become a cause of trouble.

Perhaps one of the most useful pneumatic tools for the foundry is the pneumatic rammer. At first looked upon with disfavour by many craftsmen, its use is becoming more and more popular. To get the best results it is necessary for the operator to appreciate the action of the tool, and remember that the blow is made by the action of the compressed air, consequently it is not necessary to press in the rammer, but simply hold it in the desired position and guide it over the face to be rammed. After a little practice workmen get quite skilled in the use of these air-operated rammers, and the writer has found that a good man will produce certain work by the aid of such a tool cheaper than similar work could be made on certain types of moulding machines.

[Another suggestion is that provision should be made to hang coiled hose on the wall when not in use, as many have been ruined through receiving splashes of liquid metal.—EDITOR.]

EIREANN IMPORTS OF PIG-IRON in May, 1946, were 198 tons, valued at £2,185, against 30 tons (£371) in May, 1945. Exports of bog iron ore during the same period were 6,346 cwts. (£328), against 9,647 cwts. (£482) in May, 1945.

METHODS OF MAKING CAST-IRON SHELLS

Reviewed by MR. B. LEVY

In the May 30, July 4 and 25 issues of the FOUNDRY TRADE JOURNAL appeared a problem, its solution, and ultimately some correspondence pointing out an obvious discrepancy in the solution. The problem referred to is that of making cast-iron shells, and would appear to have a number of practical

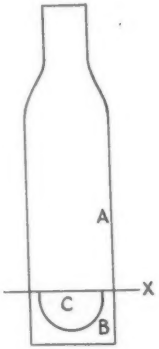


FIG.1

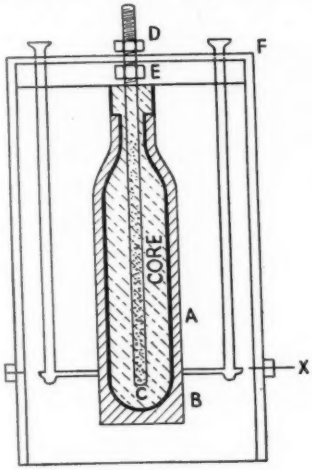


FIG.2.
SOLUTION 2.

methods applicable to obtaining satisfactory results, an extract of proposals has now been correlated, and is as follows:—

MR. P. JAMISON, of Brown Square Iron & Brass Foundry, Limited, Belfast, suggests a method (Figs. 1, 2 and 3) which is based on the same principle as that adopted in making trench mortar bombs in the 1914-18 war. With reference to the diagram "Solution 2," the pattern is made as in Fig. 1, in two parts—A and B, with a joint at X. Bottom B is machined to form cup C to support the core for position in the mould. The moulding box in Fig. 2 can be made in two or three parts (in the sketch it is in two parts), as the main problem is in securing the core in a concentric position. The mould is rammed as suitable to the foundry, with the joint at X. Pattern A is drawn from the mould, leaving B; then the core is placed in cup C. The top of the mould is closed over the core, and secured by nut E to hold it down, and by nut D, to hold it up. Bridge F on top of the moulding box is for this purpose. The top portion of the mould is now lifted with the core in position, and the cup part of the pattern removed. The mould is now ready for closing, and prepared for casting. The gating, circular ring ingates, and the core barrel are shown in the sketches.

No doubt this method would be quite good provided attention was paid to the following details. First, adequate taper on the coreprint (not indicated in Mr. Jamison's sketch) would, of course, be necessary, and a check washer or nut at the nose of the core barrel desirable. A still more important feature to be watched is to provide positive means of centring the core barrel in the centre of the core at the time of core-making. Further, it would appear equally important to have an extension on the top of the pattern to provide a locating or starting position so far as the pattern and mould is related to the hole in the top of the bridge F.

FIG.3.

The reviewer's additions as last indicated would not eliminate the difficulties in closing the top-part over the core, and the dangers of a dirty casting attaching thereto, nor could this method be called a particularly fast production system.

MR. W. D. POWELL, of York, submitted a somewhat similar solution (Solution 3) to Mr. Jamison's, and whilst indicating the necessary taper on his coreprint omitted the detail of coreplacing, centring of core barrel and bridge of moulding box which in summary have the same pro's and con's as Solution 2.

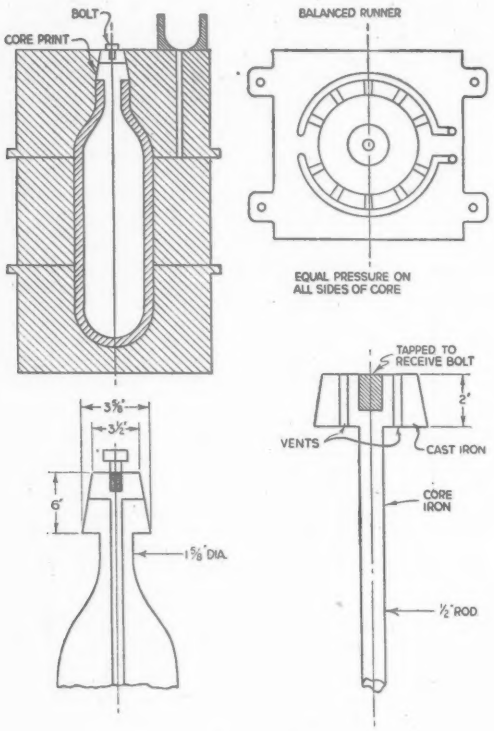
MR. W. GUDGEON, of Preston, has also proposed a solution (Solution 4) on very similar lines to the aforementioned solutions, giving as his example a shell which must have been rather larger at the neck than the job in question, because the core barrel diameter used on Solution 4 was 1½ in. in diameter, thus leaving only $\frac{1}{16}$ in. of sand around the barrel for this size shell—obviously inadequate in this instance and necessitating at least a smaller diameter core barrel. The method of supporting the core in the top-part of Mr. Gudgeon's proposal was by a flat on each side of the core barrel and the employment of a double wedge to fit over these flats, thus tightening the core in its position.

Here, again, the reviewer would comment that the same points of criticism as applied to Solution 2 would still obtain. It was interesting to note under the last solution's system that 400 trench mortar bombs were cast per day using no oil sand, and further, that the problem of keeping the core central was also of some considerable moment.

As a final contribution to the correspondence on this subject, the reviewer gives his own (perhaps daring) method (Solution 5), making no claim to having tried, tested, or seen the system carried out, but

Methods of Making Cast-iron Shells

nevertheless possible of exploration. A single pattern is provided split accurately through the vertical centre line, allowing each half to be matched end to end

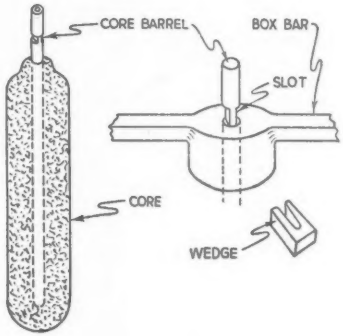


SOLUTION 3.

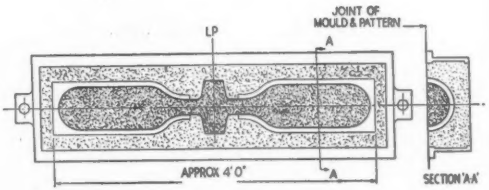
forming a centre locating print as shown at LP—Solution 5. The two half patterns are mounted on to a plate centrally with the box pin holes, thus forming a twin half-pattern or "dumb-bell" shape.

Ramming of moulds.—Off the pattern as mounted on a plate horizontally, by hand, machine or Sand-slinger. Top and bottom parts can be both made off the one half-pattern-plate, but for fast production two such plates (matched) would be desirable, having the runner and gating system then incorporated. Cores are produced off one half corebox embodying the full length shape of a twin core as will now be seen required. The cores now are self-balancing and misplacement when coring-up the mould would be immediately visible and eliminated to the greatest possible exicnt.

The method of running and ingates would possibly necessitate a little experiment to ensure a pressure-tight casting and in any case the pouring would be possible as the mould is rammed, *e.g.*, horizontal or by inclining the whole assembly or even vertically, *viz.*, through end of box parts. Individual casting would not present any risk as each casting is sealed off completely by the centre check-portion of the core, LP. In all positions the core, being in perfect balance and held by its centre locating print, should be quite rigid, and accuracy of castings accordingly maintained.



SOLUTION 4.



SOLUTION 5.

THE ADDRESS OF THE Worcester office of British Insulated Callender's Cables, Limited, is now 37, Broad Street.

THE CLOSING DATE for entries for the W. H. Whittle Foundation, the short Paper competition open to all junior technicians of the enamelling industry, has been extended to August 31, 1947, in view of the return of many junior technicians from the Forces. Full particulars may be obtained from the hon. secretary of the Institute of Vireous Enamellers, Mr. W. Thomas, Rickmansworth Road, Chorley Wood, Herts.

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PEARSON & KNOWLES COAL & IRON COMPANY

LIQUIDATION DEPENDENT UPON PURCHASE CONSIDERATION

In a statement circulated with the annual report of the Pearson & Knowles Coal & Iron Company, Limited, Sir Peter W. Rylands, Bt., the chairman, says that the conduct of the company's affairs during the last 16 years has been a long and uphill task. The Pearson & Knowles Company sold their steel and coal assets to the Lancashire Steel Corporation, Limited, and the Wigan Coal Corporation, Limited, respectively, in 1930, and the balance sheet which he presented to the shareholders at that time showed a liability in respect of 5 per cent. income debenture stock of £943,540, and in respect of a bank loan of £480,000. On the other side of the balance sheet, while the value of the assets at that date was exceedingly uncertain, there was a deficiency account, uncovered by assets, amounting to £682,849. "A depressing picture and a position probably regarded by many as hopeless," Sir Peter continues. Their directors, however, refused to be discouraged, believing that the ultimate prospects of the Lancashire Steel Corporation and the Wigan Coal Corporation were bright, assisted by the adoption by the Government of the principle of a duty upon imports of steel on the one hand, and the development of what he believed to be the extremely valuable coal resources of the Wigan Coal Corporation on the other, although there could be no doubt that many years must elapse before these hopeful anticipations could be realised. The ultimate aim of the directors was to create a condition when liquidation of the company would be possible and the shareholders should receive 20s. in the £.

"I think the satisfactory position of the company to-day has been reached sooner than could reasonably have been expected 16 years ago," Sir Peter adds. During those years the liability in respect of the income debentures had been reduced by £341,442 to £602,098, while the bank loan of £480,000 had been completely extinguished, and the deficiency account reduced from £682,849 to £10,681. It was now possible for the directors to recommend the distribution of a dividend at the full rate of 6 per cent. on all the preference shares, which they hoped it would be possible to maintain in the future until such time as liquidation of the company became practicable. The realisation of this hope, however, was dependent upon the share of the purchase consideration awarded in the recent arbitration, under the Coal Nationalisation Scheme, which would be received by the Wigan Coal Corporation, and that, at present, was "anybody's guess."

A CLAIM BY THE MEN employed by the Geevor Tin Mines, Limited, and by South Crofty, Limited, for an increase of 2s. per shift to all workers was referred to the National Arbitration Tribunal, which, in an award just issued, finds that the claim has not been established.

AUGUST PIG-IRON AND STEEL PRODUCTION

Steel production during August was at the rate of 11,747,000 tons a year, compared with 9,465,000 tons in August, 1945. In both years production was affected by holidays.

Pig-iron output was also higher, the annual rate of August production being 7,558,000 tons, compared with 6,358,000 tons for August, 1945.

The table below shows pig-iron and steel production in August (in tons), with previous figures for comparison:—

	Pig-iron.		Steel ingots and castings.	
	Weekly average.	Annual rate.	Weekly average.	Annual rate.
1946—1st quarter ..	145,500	7,566,000	242,600	12,617,000
2nd quarter ..	150,000	7,827,000	252,100	13,111,000
July	147,000	7,645,000	226,000	11.759,000
August	145,300	7,558,000	225,900	11,747,000
1945—1st quarter ..	134,500	6,992,000	233,200	12,126,000
2nd quarter ..	132,600	6,894,000	227,200	11,814,000
July	134,800	7,010,000	213,800	11,118,000
August	122,300	6,358,000	182,000	9,465,000

AUSTRIAN IRON AND STEEL INDUSTRY

OUTPUT INCREASING

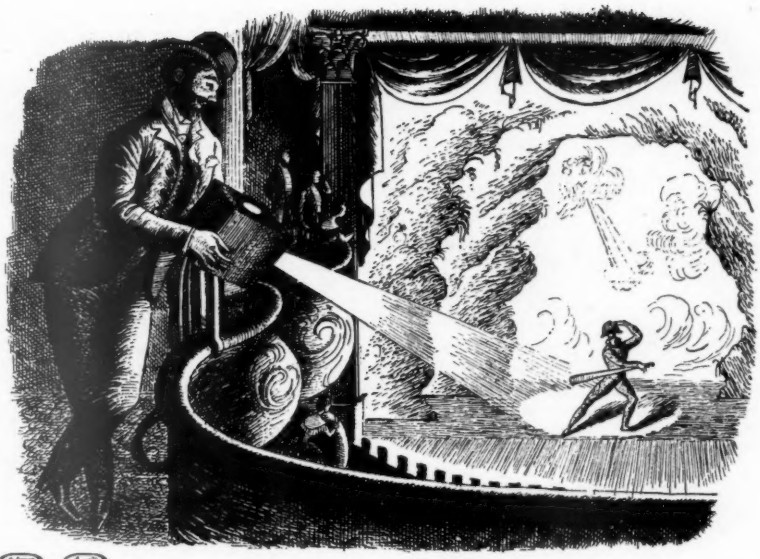
In July, iron-ore production in Austria totalled 55,000 tons (49,000 in Styria and 6,000 in Carynthia), compared with 30,960 tons in June, an increase of about 75 per cent. A contributory factor to this increase was the reopening of Radmer mine in Styria. Steel production went up to 12,600 tons, compared with 8,700 tons in June, an increase of 38 per cent.

The experimental use of Soderberg-type, continuous-feed electrodes in the place of the solid carbon or graphite electrodes, used in electric furnaces, is meeting with some success.

Under the terms of the recent Austro-Czechoslovakian trade agreement, Austria undertook to deliver 640,000 tons of steel and magnesite. It is stated by the British occupation authorities that some 280,000 tons has already been delivered.

LICENCES FOR U.S. IRON AND STEEL EXPORTS

The U.S. Department of Commerce has announced that in future individual licences will be required for the export of steel sheet bars and tinplate bars without alloy, concrete reinforcement bars, other hot-rolled steel bars, without alloy, of 1 in. and under, wire rods, skelped iron and steel, black ungalvanised unalloyed steel sheets, black iron sheets, cold-rolled unalloyed iron and steel strip, and various structural shapes, pipes, pipe fittings, bale ties and tinfoil.



1886

Sixty years ago the use of oxygen was almost entirely confined to the magic-lantern-like spotlights of the Victorian theatre, and the daily output was measured in a few hundred cubic feet. Today, in the service of industry and medicine, many millions of cubic feet are produced daily. Its use embraces such diverse applications as the conditioning, cutting and welding of steel, oxygen supply for high altitude flying, and anaesthesia and resuscitation. The British Oxygen Co. Ltd. is proud of the part it has played during the last sixty years in making the oxygen now so indispensable to industry and medicine.

1946

The British Oxygen Company Ltd

London and Branches

IN THE SERVICE OF INDUSTRY AND MEDICINE FOR SIXTY YEARS

PERSONAL

MR. J. S. HORSEFIELD has resigned from the board of Associated Clay Industries, Limited.

SIR EDWARD J. GEORGE has resigned his seat on the boards of the Consett Iron Company, Limited, and the Consett Spanish Ore Company, Limited.

MR. A. F. AIKEN, manager of the metal foundry of the Hoyt Metal Company of Great Britain, Limited, of Putney, London, S.W.15, for 32 years, has retired.

MR. L. C. MONTAGUE has been appointed a director of Johnson, Matthey & Company, Limited, precious metal smelters, refiners and engineers, of Wembley.

MR. JAMES HAIG, assistant foreman moulder with Dobbie, Forbes & Company, Limited, of Larbert, has received a monetary gift on the completion of 50 years' service.

MR. G. VARLEY has been appointed to the board of Textile Machinery Makers, Limited. He is a director of Platt Bros. & Company, Limited, a constituent company.

MR. H. N. G. ALLEN, a director of W. H. Allen, Sons & Company, Limited, Queen's Engineering Works, Bedford, has been elected to a seat on Bedfordshire County Council.

MR. J. CLIFFORD WOOD, commercial manager of John Fowler & Company (Leeds), Limited, manufacturers of agricultural machinery, etc., has been appointed a director.

MR. DAVID REILLEY, production manager of the Lancashire & Corby Steel Manufacturing Company, Limited, has been appointed general manager of the British Rolling Mills, Limited.

SIR ARCHIBALD F. FORBES has, at the request of the Government, been released from his executive duties with Spillers, Limited, following his appointment as chairman of the Iron and Steel Board.

MR. ELLIS FLOWER, a past-president of the Lancashire branch of the Institute of British Foundrymen, has commenced business as a master patternmaker at the Melling Mill Works, Eccleston, St. Helens, Lancs.

MR. J. HEPBURN, formerly commercial director of Davidson & Company, Limited, Sirocco Engineering Works, Belfast, has been appointed managing director of Musgrave & Company, Limited, St. Ann's Ironworks, Belfast.

SIR ALFRED HERBERT, head of Alfred Herbert, Limited, machine-tool makers, importers and exporters, of Coventry, celebrated his 80th birthday on September 5. He has been president of the Machine Tool Trades Association for more than 20 years.

MR. J. W. CLEMISHAW has been presented with a cheque by the directors of Joseph Webb & Sons, Limited, Irwell Forge, Bury, Lancs, as a token of their appreciation of his 50 years of continuous service. He is cashier of the company.

SIR RICHARD A. PEASE, BT., a director of Pease & Partners, Limited, pig-iron makers, coke producers, etc., the Skinningrove Iron Company, Limited, and of the Brush Electrical Engineering Company, Limited, has been elected president of the National Benzole Association.

MAJOR PETER ROBERTS, M.P., has joined the board of directors of Newton Chambers & Company, Limited. He is also a director of several coal concerns and of the Wellman Smith Owen Engineering Corporation, Limited. The new director is an enthusiastic supporter of closer understanding and co-operation between the workpeople and management. He has served in the ranks as a soldier, and was later commissioned and transferred to the H.Q. staff. Trained as a barrister, he has travelled widely in connection with the study of coal, iron and steel.

MR. C. W. KAYSER has resigned his position as chairman and managing director of Kayser, Ellison & Company, Limited, makers of high-class crucible and electric steels, of Sheffield, but will continue as a director. He has been associated with the company for 58 years and has been chairman and managing director for the past 40 years. The new chairman and joint managing director is MR. L. A. K. HALCOMB, a director since 1919 and deputy chairman and joint managing director for the past five years. MR. P. B. HENSHAW, who becomes deputy chairman and joint managing director, has been a director since 1915. He was appointed joint managing director in 1941. MR. E. RANSOM HARRISON will join the board shortly. MR. H. FRANCIS, who formerly represented Kayser, Ellison & Company in the Midlands, is retiring from the board.

MR. WALTER W. STEVENSON, assistant director of the research and development department, the United Steel Companies, Limited, has been appointed chief metallurgist of Dorman Long & Company, Limited, Middlesbrough. A native of Chesterfield, Mr. Stevenson received his early metallurgical training at the Brown-Firth Research Laboratories under the late Dr. W. H. Hatfield. In 1927 he was appointed chief chemist in these laboratories and five years later joined the late Dr. T. Swinden in building up the central research department, Stocksbridge, of the United Steel Companies, where he was head of the chemical section. Last year Mr. Stevenson became assistant director of the research and development department, acting as liaison between the company's central laboratories and branches with particular reference to coke ovens, blast furnaces and mass-production steel-making plants. A Fellow and member of the Council of the Institution of Metallurgists, Mr. Stevenson is a member of numerous scientific bodies and has published many scientific papers.

Wills

ALLAN, J. H., retired ironfounder, of Dumbreck, Glasgow £11,466

WHARMBY, W. F., chairman of the Meadow Foundry Company, Limited, of Mansfield £11,660

YUILLE, J. W., of Glasgow, formerly a director of the Falkirk Iron Company, Limited £58,538

WELLS, J. A. E., a director and foundry manager of Edgar Allen & Company, Limited, Imperial Steel Works, Sheffield £24,379

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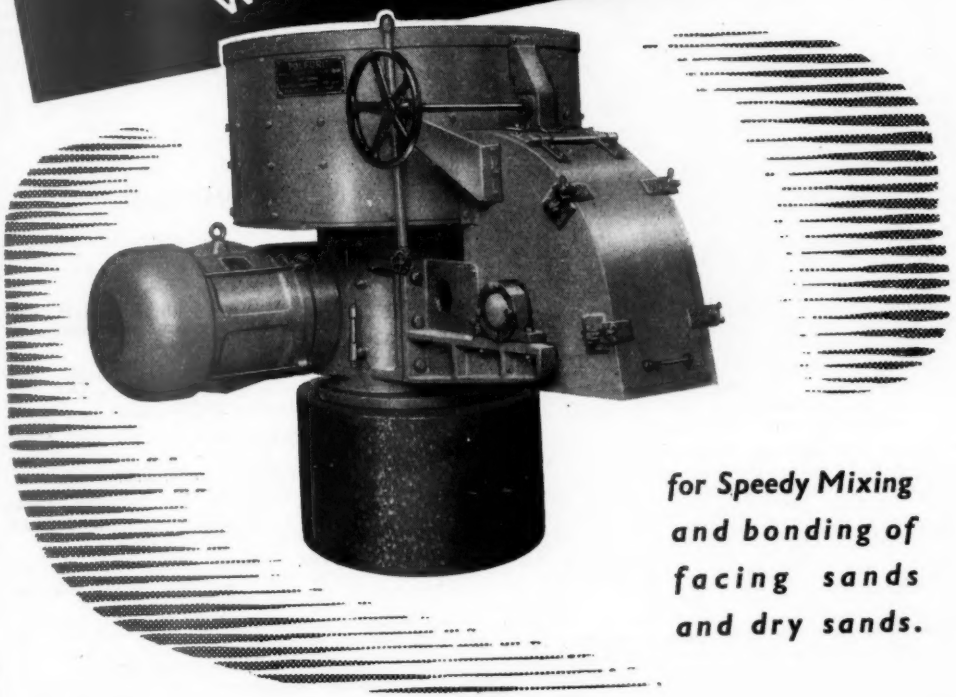
"POLFORD" REGISTERED MOTOR DRIVEN MIXER MILLER WITH DISINTEGRATOR



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COMPANY RESULTS

(Figures for previous year in brackets.)

William Blythe & Company—Interim dividend of 10% (5%).

British Aluminium Company—Interim dividend of 2% (same).

Quirk, Barton & Company—Interim dividend of 2½% (same).

T. M. Birkett & Sons—Final dividend of 10%, making 15% (same).

Brcedon & Cloud Hill Lime Works—Interim dividend of 7½% (same).

International Nickel Company of Canada—Quarterly dividend on the preferred shares of $1.75 (same).

Brightside Foundry & Engineering Company—Dividend of 1s. 9d. (same), plus 6d. (3d.) bonus, per 5s. share.

Lochgelly Iron & Coal Company—Profit for the year ended May 31 £179,378 (£82,744); dividend of 15% (10%); forward, £111,352 (£28,065).

Metal Traders—Net profit, including tax recoverable, for the year ended March 31, £9,545 (£7,027); dividend of 37½% (25%); forward, £106,586 (£105,616).

Metal Closures—Final dividend of 17½% (12½%), making 30% (25%), and a capital bonus of 10 per cent., tax free, payable out of profit from the sale of the subsidiary company.

Associated British Engineering—Net profit for the year ended March 31, £23,630 (£14,839); dividend equalisation account, £3,000 (£2,000); dividend of 12% (8%); forward, £8,587 (£5,734).

Titanine—Net profit for the year ending March 31, £20,862 (£26,559); final dividend of 10%, making 20% (same); to reserve, £5,000 (£10,000); to staff benefit fund, £2,000 (same); forward, £1,876 (£4,014).

Leeds Fireclay Company—Profit for the year ended June 30, £17,813 (loss £10,830); dividend of 5% (nil) on the 6% non-cumulative participating preference shares; to deferred renewals fund, £5,000 (nil).

West's Gas Improvement Company—Profit for the year ending March 31, after tax, £16,359 (£12,039); final dividend of 10% (5%), making 20% (10%) and bonus of 2½% (nil); forward, £32,147 (£28,450).

Hartley & Sugden—Net profit for the year ended June 30, £7,521 (£2,560); provision for taxation, £3,600 (nil); deferred repairs, £2,000 (nil); to general reserve, £2,000 (nil); dividend of 6% (5%); forward, £3,093 (£2,228).

Fodens—Trading profit for the year ended May 31, after providing for depreciation, £136,194 (£154,203); taxation, £86,776 (£120,137); net profit, £50,594 (£37,068); dividend of 9% (same); to general reserve, £35,000 (£20,000); forward, £21,347 (£23,194).

Walker Bros.—Net profit, before taxation, for the year ended March 31, £23,987 (£28,203); taxation, £12,073 (£14,165); dividend of 7% (same); to sinking fund for redemption of debenture stock, £2,077 (£1,983); to sinking fund for redemption of preference shares either by purchase or drawing before December 31 next, £6,813 (nil); alterations to buildings, nil (£9,000).

Tata Iron & Steel Company—Net profit for the year ended March 31, after tax and depreciation, Rs. 3,11,62,353 (Rs. 3,21,71,814); brought in, Rs. 11,00,179 (Rs. 2,00,19,267), plus income-tax recovered from dividend on preference shares (1944-45), Rs. 16,78,445 (Rs. 15,90,087); to reserve, Rs. 70,00,000 (Rs. 85,00,000); ordinary dividend of Rs. 23 per share (same) and of Rs. 129.8.9 (same) on deferred shares.

Pearson & Knowles Coal & Iron Company—Net profit for the year ended June 30, £32,336; dividend of 6 per cent. on the "A," "B," and "C" preference shares (nil), leaving £5,108 applied in reduction of the deficiency account. The directors have decided that the suspense account arising out of the liquidation of the Partington Steel & Iron Company, Limited, and amounting to £376,079, is no longer necessary, as they are of the opinion that the company's investments are in the aggregate worth their par value. The suspense account has accordingly been utilised to reduce the deficiency account. This, together with the surplus from the operations of the company for the past year, reduces the deficiency account to £10,681.

NEW COMPANIES

("Limited" is understood. Figures indicate capital. Names are of directors unless otherwise stated. Information compiled by Jordan & Sons, 116, Chancery Lane, London, W.C.2.)

Price & Bayliss (West Bromwich), 12, Carters Green, West Bromwich—Electrical and general engineers, etc. £2,000. W. S. Price and V. G. Bayliss.

Hollins (Stockholders), Dimsdale, High Park Crescent, Sedgley, Staffs—Iron and steel stockholders, etc. £5,000. F. W. Hollins and T. Emms.

Factory Installations, 48, Northgate Street, Leicester—Mechanical and electrical engineers, etc. £2,000. E. A. Blackburn and C. D. Frost.

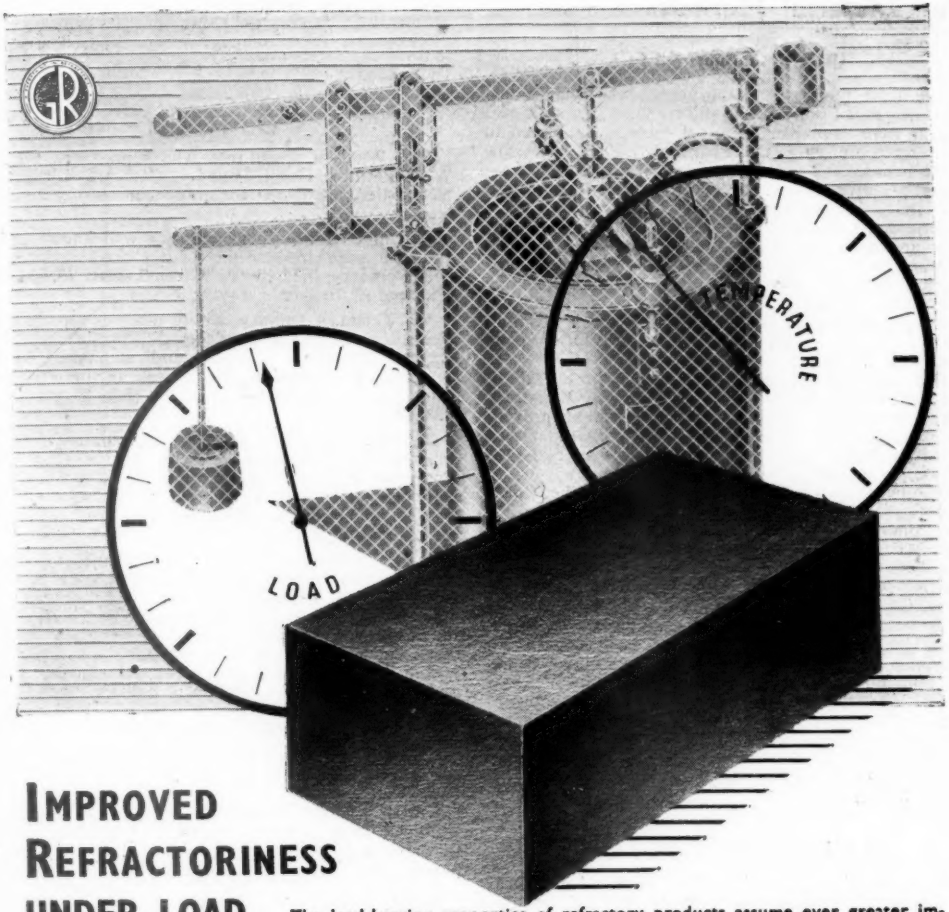
Overton Plating Company, 25, Newman Street, London, W.1—Electro, nickel and chromium platers, etc. £1,000. G. J. and A. P. G. Grimes.

Halliday, Crofts & Company, Carr Mills, Buslingthorpe Lane, Leeds—Manufacturers of pipes, stoves, etc. £1,000. J. Halliday and L. L. Crofts.

Riley Stapletex, Globe Machine Works, Stoke Street, Rochdale—Textile engineers, etc. £1,000. A. Dewhurst, S. T. and M. Diggle, N., T. B., and E. Riley.

H. Brooksbank (Sheffield), 145, Eldon Street, Sheffield—Makers of aluminium goods. £5,000. H., R. H., H. L., T. A., and H. Brooksbank.

A. Jeffrey & Company, 75, Buchanan Street, Glasgow—Manufacturers of steel moulders' composition. £10,000. I. Jeffrey, A. Mair, and C. W. Gibb.



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Raw Material Markets

IRON AND STEEL

The light foundries remain very busy and would increase their production still further if additional labour were available. Most of them are prepared to take up more than the quantities of pig-iron now being licensed. The jobbing foundries have been consistently active throughout the war period and since, and the speciality and engineering foundries, which experienced a pause in production earlier in the year, also are now very busy. The supply of pig-iron appears to be sufficient to take care of current production, but their cannot be much margin. Hematite and refined brands are slightly easier to get than low- and high-phosphorus grades. In view of this position, the use of scrap of all kinds is continuing on as large a scale as possible.

The allocation scheme for coke is now in operation, and reasonable supplies are reaching the foundries. Where the need for a larger tonnage can be proved, the necessary coke seems to be going forward. Other foundry supplies, such as limestone, ganister and firebricks, are available in satisfactory quantities.

The tightness of supply in the semi-finished steel department is still very pronounced. There is hardly a re-roller who is not pressing for larger deliveries, particularly for 2-in. to 3-in. billets. At the moment, very little semi-finished steel is being imported and, granting the desire, the Control would not find it easy to secure large tonnages for early delivery. Under these conditions, defective billets, crops, etc., are quickly taken up.

Makers of steel plates and sections are fully booked and hold business for delivery well into 1947. Some attractive export orders are available, but are difficult to place because of the urgent home demands. The demand for sheets continues to be as strong as ever, and the sheet-bar position does not help the rollers. The rolling mills are also suffering from a shortage of skilled workers.

NON-FERROUS METALS

Market opinion generally is that the trend of prices of non-ferrous metals must still be upward. Few of the metals are really plentiful, and some concern is being shown about copper in particular. The higher price for aluminium shortens the margin between copper and the light metal, but there are not lacking observers who visualise a price of £100 for copper. A considerable loss in copper output has been experienced this year, and the Ministry of Supply must be concerned about prospects during the coming months. Reserves of zinc and lead are by no means high. Tin production appears to be increasing, but the metal must remain in short supply for some time yet. Colonial Office figures show that tin production in Malaya in the second quarter of this year was 2,260 tons, compared with 786 tons in the first three months. Seven dredges were operating at the end of June, against four in the previous quarter, while a further 25 were being rehabilitated at the end of the June quarter. The number of mines working was 151, an increase of 61.

OBITUARY

MR. WILLIAM HAMILTON, who represented G. & J. Weir, Limited, Holm Foundry, Cathcart, Glasgow, at Newcastle-upon-Tyne, for more than 40 years, died recently.

MR. BENJAMIN TAYLOR, who was well known in iron and steel trade circles in the Nottingham area for nearly half a century, died on September 7, aged 78. He was principal of Benjamin Taylor & Son.

MR. CHARLES DUNBAR, whose death is reported, was vice-chairman and a managing director of the British Oxygen Company, Limited, and a pioneer in the commercial production of oxygen, an industry with which he was associated for more than 50 years. He was 69.

BRIG.-GENERAL GEOFFREY MEINERTZHAGEN JACKSON, chairman and managing director of the Clay Cross Company, Limited, died at Clay Cross Hall, Derbyshire, on September 9. He was 77 years of age. In February, 1941, he completed 50 years' association with the company.

MR. J. M. RINGQUIST, who retired at the end of 1941 after 46 years' service with Head, Wrightson & Company, Limited, Teesdale Ironworks, Thornaby-on-Tees, died on September 6 at Stockton-on-Tees. He joined the firm as a draughtsman and subsequently became chief engineer and a director. During his career with Head, Wrighton & Company, Mr. Ringquist designed and superintended the erection of colliery plants, blast-furnace plants, dock and harbour works, coal-handling plants and many other large undertakings. He was also responsible for many patents.

KODAK, LIMITED, of Wealdstone, Harrow, Middlesex, announce that they are prepared to receive applications for participation in a two weeks' course in weld-radiography. Details are available on application.

BEYER, PEACOCK & COMPANY, LIMITED, locomotive engineers, foundrymen, etc., of Manchester, are to redeem on February 15, 1947, the whole of the outstanding 5 per cent. debenture stock at £105 for every £100 nominal of stock plus a sum equal to interest (less income tax) calculated from January 1, 1947. There is £94,328 of this stock outstanding.

IN HIS PRESIDENTIAL ADDRESS to the Institute of Marine Engineers, last week, Sir Amos L. Ayre, permanent chairman of the Shipbuilding Conference, spoke of the possibility of greatly increased speeds in ship propulsion from the use of atomic energy. The use of nuclear energy for the propulsion of high-powered ships now appeared to be on the horizon, though perhaps somewhat distant.